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ON THE SOUTH AMERICAN SPECIES OF THE DIPTEROUS GENUS CHIROMYZA WIED.

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In the recently published Revision of the Chiromyzini by Mr. G. H. Hardy* Australian forms only have been dealt with. In the present paper the writer will take into consideration South American forms only.

Agreeing with Verrall (Brit. Flies V, p. 44) the Chiromyzini are accepted here as a tribe of the family Stratiomyiidæ, chiefly on account of the form and position of the præfurca; but they have many important characters in common with the Rhagionidæ.

The main character of the tribe is that of the atrophied mouth parts, which must be in correlation with some peculiar habits of the adult flies. In addition may be recorded the sunken face and the greatly developed and apparently bisected front coxæ. The third antennal joint is more or less distinctly annulated; the last abdominal segments of the female are ovipositor-like; the tibiæ are not spurred. The wings have the ambient vein complete, even if sometimes very thin; a short præfurca; only 4 posterior cells, all open; the anal cell closed and stalked, but long.

Because of the normally developed mouth parts the genus *Allognosta* must be placed in the *Beridini*.

A peculiar feature of the Chiromyzini is the great variability in venation of the wings. Mr. Hardy points out that in

*Proceedings of the Linn. Soc. of N. S. W. XLV, 1920, p. 532-542, pl. XXIX-XXX.

Australian forms even the upper branch of the cubital fork may be variable, being present in some specimens of one species and wanting in others. I have never found this to be the case with South American forms, which all have an unforked cubital vein, except in *Hylorus*. I have observed the following anomalies:

(*a*) The hind cross-vein may be more or less obliterated, in part or as a whole, the discoidal cell being thus partly or entirely open.
(*b*) The third vein issuing from the discoidal cell may be quite wanting or represented by a short stump.
(*c*) The ambient vein may be sometimes rather indistinct, chiefly in female specimens.

It is evident that this variation by reduction refers chiefly if not exclusively to the veins of the hind half of the wings. It may be interpreted as a condition of the true Stratiomyiid flies, in which the veins of the fore half only are thickened and crowded together near the costa, and as a tendency toward degeneration of wing, a fact which has reached its climax in the Australian genus *Boreoides* with subapterous females.

The South American genera of the tribe may be distinguished as follows:

1. (2) Third longitudinal vein forked; eyes bare and united in the male; third antennal joint with numerous annulations.....*Hylorus* Phil.
2. (1) Third longitudinal vein simple; third antennal joint with less than 8 annulations.
3. (6) Eyes of male united, quite bare or with few and scattered hairs; third antennal joint more or less distinctly annulated or even simple.
4. (5) First antennal joint much longer than the second, being as long as the third.....*Inopus* Walk.
5. (4) First antennal joint as long as the second and much shorter than the third; metapleura with short hairs; wings with microscopical pubescence and with the first longitudinal vein clothed with short hairs.....*Chiromyza* Wied.
6. (3) Eyes of male broadly separated, and clothed with abundant and short hairs; third antennal joint with deep annulation, and much longer than the first; metapleura with long hairs; wings with long pubescence and with the first longitudinal vein clothed with long hairs.....*Barbiellinia*, n. genus

I. **Hylorus** Philippi.

The unique South American form with forked third longitudinal vein, only known by the type species *Krausei* Phil. from Chile. Placed in *Chiromyza* by Hardy; not seen by the writer.

II. **Inopus** Walker.

The unique South American form with elongated first antennal joint, only known by the type species *despectus* Walker from South America. Placed by Mr. Hardy with a query in synonomy with the Australian *Metoponia rubriceps* Macq.; not seen.

III. **Chiromyza** Wiedemann.

The genus *Xenomorpha* Macquart, with the type *leptiformis* Macq. from Rio Janeiro, is evidently the same; likewise the genus *Nonacris* Walker.* with the type *transequa* Walk. from South America; and even the genus *Lagarus* Philippi with the type *paulseni* Phil. from Chile, and *Lagarinus* Enderlein with the type *paradoxus* End. from Chile, as pointed out by Mr. Hardy.

It may be noted that in the original figure of the type species by Wiedemann the second longitudinal vein of the wings was omitted, perhaps accidentally. This vein is well shown in the figure of *Xenomorpha* by Macquart.

The South American forms before me can be distinguished as follows:

1. (8) Anal cell long, its terminal stalk being much shorter than the preceding part of the postical vein; halteres and coxæ of a pale yellowish color.
2. (7) The fourth longitudinal vein is forked before the hind crossvein, which is always complete; the second posterior cell is therefore sessile and rather obtuse at base; the third vein issuing from the discoidal cell frequently present in the shape of a short stump; scutellum never greenish.
3. (4) Back of thorax with four longitudinal dark stripes; pleuræ with several blackish spots.....*vittata* Wied.
4. (3) Thorax with three longitudinal stripes only, or not evenly striped.
5. (6) The 3 dark stripes on thorax are broad and partly confluent, the back appearing thus in great part infuscated.....*fuscana*, Wied
6. (5) The above named stripes less developed and often obliterated, the back appearing for the most part reddish yellow.....*ochracea* Wied.
7. (2) The fourth vein forks beyond the hind cross-vein, which is often obliterated in its upper portion, or quite wanting; the second posterior cell is therefore acute at base and mostly provided with a short stalk; the rudiment of the third branch of media is never present; sides of thorax and of scutellum greenish.....*viridis* n. var.
8. (1) Anal cell rather short, its stalk being about as long as the preceding portion of the postical vein; the whole antennæ, the halteres and the coxæ quite black.....*nigra* n. sp.

1. **Chiromyza vittata** Wied. (**leptiformis** Macq.)

As shown in the original figures by Wiedemann and by Macquart, the main character of the present form is that of the divided middle dark stripe of the back of mesonotum, which has therefore 4 longitudinal stripes. I have in my collection 3 female specimens from S. Sebastiao, seashore of the State of S. Paulo, Brazil, collected by the Count *A. A. Barbiellini*. They agree in having the discoidal cell broad and obtuse outwardly, the second posterior cell with broad sessile base, the anal cell with short terminal stalk. One specimen only shows the short basal rudiment of M 3. The scutellum of the female has a shining black depression on each side at base; the same depression in the male is reddish or only a little darkened.

*It must be noted that in the original description for "Fourth posterior areolet closed before the border", the anal cell is meant.

2. **Chiromyza vittata fuscana** Wied.

Numerous specimens of both sexes, some in copula, from Puerta Bertoni, Alto Parania, Paraguay, June, 1919, collected by Mr. C. Schrottky. One male specimen from S. Sebastiao, Brazil, by *A. A. Barbiellini.*

These specimens agree in having the middle dark stripe of thorax undivided, and usually prolonged behind to the scutellum; the back of mesonotum is broadly infuscated; the dark spots of the pleuræ are less developed; the scutellar depressions as in the preceding.

The venation is as in *vittata;* the rudiment of M 3 is present in 11 specimens of 12. There are frequently abnormal cross-veins in the base of the second posterior cell, forming 1–4 small supernumerary cells; they are present in all the female specimens, but are not symmetrically placed, being often present on one wing only.

3. **Chiromyza vittata ochracea** Wied.

(? *transequa* Walk.)

This is the palest of all the forms, with unspotted pleuræ and bright orange abdomen.

One male specimen from S. Paulo, Brazil, March, 1906 (R. von Ihering). Agreeing in venation with the preceding forms; there is no rudiment of M 3.

4. **Chiromyza vittata viridis** n. var.

Two males from S. Paulo, Brazil (*A. A. Barbiellini*). They seem to agree with *ochracea* Schiner in being more slender than the preceding forms.

Male, length of body, 8–9 mm.; of wing, 8–9 mm.

Eyes closely approximated, but a very small stripe of the frons is visible between them. Third antennal joint twice as long as the two first joints together, black, pilose, distinctly annulated.

Thorax reddish on the back, with three less marked dark longitudinal stripes; pleuræ pale yellowish, unspotted; the sides of the back posteriorly and the border of the scutellum are distinctly greenish. Halteres pale yellow as in all the preceding forms. Abdomen entirely orange, more pale on the venter. Coxæ and legs entirely pale yellowish, with last tarsal joint blackened; trochanters greenish. Wings yellowish, hyaline. One of the two specimens has the discoidal cell complete; in the other only a stump of the hind cross vein is present inferiorly, the cell being broadly open. Both specimens have the second posterior cell acute at base and there provided with a short stalk, which forms a common basal stem for M_1 and M_2; the discoidal cell is acute outwardly; there is no rudiment of M_3; the terminal stalk of the anal cell is short as usual. The present species shows that the condition of *Lagarinus* is a casual one; but Enderlein's species has the third antennal joint not annulated.

5. **Chiromyza nigra** n. spec.

Type ♂, a single specimen in the writer's collection from Ecuador, received many years ago from Dr. J. Escher-Kundig, Zurich, Switzerland.

This may be a melanic mountain form, but it is here described as specifically distinct, chiefly on account of the peculiar shape of the anal cell, which recalls the condition of this same cell in the Beridinæ.

♂ Length of body 11 mm., of wing 10 mm.

Head entirely black, but the occiput and the face densely covered with a dark gray dust. Ocellar tubercle deep black. Eyes bare, intimately united, no distinct line being visible between them. Antennæ entirely black; the 2 basal joints are of about equal length; the third joint is only a little longer than the two first joints together; it is pilose, but I cannot perceive trace of its annulation because of its bad preservation. Mouth parts rudimentary as usual.

Thorax blackish-brown on the back, more reddish on the sides, with a short darkish pubescence; pleuræ dark brownish, more pale on the sternopleura; hairs of meso- and metopleura very short. Scutellum blackish, with more pale border; lateral depressions black. Halteres with yellowish stalk, but with a black knob.

Abdomen dull black, with shining black genitalia, which have the upper lamella deeply emarginate and yellowish at end. Venter yellowish grey. Coxæ shining black, with the sutures reddish; femora yellowish, with the apical part blackish-brown; tibiæ and tarsi almost entirely blackened, only the base of tibiæ and of prætarsi being more pale; claws black, with reddish base; the 4 posterior tibiæ are thickened and a little curved as usual.

Wings greyish hyaline, with a faint yellowish tint on costal cell. Discoidal cell open, only the lower part of the hind cross vein being present; no rudiment of M_3. Second posterior cell acute at base. The two branches of M and the distal portion of upper branch of Cu are very faint, almost spurious, perhaps due to immaturity of specimen. The stalk of the anal cell is much longer than in any of the preceding forms of *vittata*, being about as long as the preceding part of the postical vein; surface of wing is microscopically pubescent as usual.

IV. **Barbiellinia** new genus.

Closely allied with *Chiromyza*, but at once distinguished by the long haired and broadly separated eyes of the male; moreover the hairs of the body, legs and wings are much more developed than in the allied forms. According to Mr. Hardy, Australian species of *Chiromyza* have either contiguous or separated eyes in the males; but the present case is the first known among Brazilian forms, and is here assumed as being of generic value on account of the unusual hairiness of the eyes.

Head rounded, rather small size, more narrow than the thorax. Occiput triangularly excavated above, with no prominent borders. The three ocelli are of rather large size, placed in an equilateral triangle on

an inconspicuous plate. Eyes rounded, with equal areolets, clothed with numerous, but not dense, long hairs. Frons with parallel sides, only a little constricted towards its middle, not at all prominent in profile, about a half of the breadth of one eye. Antennæ inserted below; the second joint being a little longer than the first; third joint as long as the two first joints together, divided into three parts by two complete and deep annulations; it is entirely clothed with rather long hairs, like the basal joints. Face receding, sunken in the middle as in the Rhagionidæ. Mouth parts rudimentary; proboscis atrophied, palpi very small. Thorax greatly developed, almost puffed up and convex above; metapleura with long, erect hairs. Scutellum elongated, rounded behind, flat above, with well developed basal depressions on the sides, destitute of longer hairs at hind border. Halteres large, with oval knob; squamulæ rudimentary. Abdomen flattened, composed of 7 segments, the last of which is only one-half as long as the preceding one; genitalia small, but open. Legs long, intermediate pair shortest. Front coxæ greatly developed and apparently bisected, the plate above them being very large; middle and hind tibiæ distinctly curved and thickened; claws and pulvilli proportionately small. Pubescence of legs and hairs of coxæ longer than in *Chiromyza*. Wings distinctly pubescent on the whole surface; first and third longitudinal veins clothed with long hairs above. Præfurca short, originating over the base of the discoidal cell. Second longitudinal vein short; third vein single, ending before the tip of the wing; costa thickened to a short space beyond the tip of third vein, but prolonged as a thin ambient vein along the whole hind border of the wing. Discoidal cell complete, about as long as broad, obtuse at its distal end; second posterior cell sessile at base, the M forking before the hind cross vein; the rudiment of M_3 is wanting. Stalk of the anal cell short, much shorter than the preceding part of the postical vein. Alula rudimentary. Hind border of the wing with rather long ciliation.

Named in honor of the Count A. A. Barbiellini, who during the long years of his residence in S. Paulo has greatly contributed to the progress of entomological studies in Brazil, by the publication of the Journal "O Entomologista Brasileiro" 1908–1910, and now by the general Review "Chacaras e Quintaes." The writer is indebted to him for large collections of Brazilian Diptera, the exposition of which will appear in the future.

Type: the following new species.

Barbiellinia hirta n. sp.

Type ♂ a single specimen in the writer's collection from Terme do Lindoya (1000 m.), Serra Negra, Eita do do S. Paulo, Brazil, March, 1918. (*A. A. Barbiellini*).

♂ Length of body 8 mm.; of wing 8 mm.

Head entirely yellowish, the occiput whitish, dusted; ocellar plate black; occipital border with a narrow white line and with erect black hairs. Frons with a narrow, less distinct, dark transverse band on the middle, whole length clothed with erect black hairs. Antennæ entirely yellowish, black haired. Hairs of the eyes black. Face with black hairs on the sides; palpi reddish. Thorax on the back yellowish-brown, with rather long dark pubescence; the middle of the dark longitudinal stripes is abbreviated behind, divided along the middle by a pale line, but the lateral ones are not distinct. Pleuræ pale yellowish, unspotted, with rather long hairs on the mesopleura, and with longer ones on the metapleura. Scutellum like the thorax, with short dark pubescence. Halteres pale yellowish, dirty on the knob. Mesonotum pale yellowish. Abdomen yellowish above, rather shining, with blackish pubescence; all the segments are narrowly black on the sides; venter pale yellowish; genitalia quite reddish, even on the upper lamella and lateral appendages. Coxæ and legs entirely pale yellowish, the last tarsal segments only being blackened; coxæ clothed with rather long black hairs, even the black pubescence of the remainder of the legs being longer than usual. All the femora are equally thin; front tibiæ thin, much more slender than the others; claws proportionally short; the three pulvilli dirty yellowish. Wings grayish hyaline, with dark yellowish veins, the basal portion of the fourth longitudinal vein being whitish.

ADDITIONAL NOTE.

Having received a paratype of *Boreoides subulatus*, through the courtesy of Mr. G. H. Hardy, and comparing it with the types of *Boreoides tasmaniensis* I have found:

(*a*) That the differences in the annulation of the third antennal joint and in the position of the hind coxæ are not consistent, these organs being not differently shaped or located in both the species.

(*b*) On the contrary the differences in the form of the scutellum, in the length of the wing-rudiments and in the coloration of thorax, are of great importance.

I find, moreover, that the legs of *tasmaniensis* are thinner and more slender than in *subulatus*, which is chiefly evident in the tarsi, which are not at all incrassated in the former. Even the color of the legs is lighter in *tasmaniensis*, the tibiæ and tarsi being entirely yellowish, while in *subulatus* they are in greatest part black. The two species are without doubt distinct; and Mr. Hardy informs me that even in Australia there are several different species of *Boreoides* not yet described.

ADDITIONAL NOTE (2).

In the meantime a paper by Dr. Günther Enderlein, Berlin, has appeared (Ueber die phyletisch älteren Stratiomyiidensubfamilien, in Mitteil. Zoolog. Mus. Berlin, X, 1921, pp. 153–214), in which a new classification of the Chiromyzini is proposed, with the descriptions of many new genera and species.

The South American species with contiguous eyes of the male are subdivided between the genera *Xenomorpha* Macquart, *Mesomyza* Enderlein and *Nonacris* Walker; while those with the separated and hairy eyes of the male are united in the genus *Chiromyza* Wiedemann. But this proceeding is evidently contrary to Wiedemann's statement, which says in the original diagnosis of the genus: " * * * *oculi maribus contigui:* * * * Augen beim Männchen zusammenstossend * * *" I am therefore of the opinion that the nomenclature used by me is more correct. The type species *vittata* Wiedemann was described only from the female sex, and thus there are no male types of it; Enderlein moreover, has not seen the female type. The genus *Inopus* is placed in synonymy with *Xenomorpha;* the genera *Lagarus* and *Lagarinus* are not mentioned at all.

CONTRIBUTIONS TO A KNOWLEDGE OF THE CRAMBINAE. II.

Crambus laqueatellus Clemens.

By GEO. G. AINSLIE,
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Crambus laqueatellus is one of the largest and most beautifully marked species in this genus and is easily distinguished from all other North American forms by the two parallel silver stripes running almost the full length of the fore wing. (Fig. II, 6).

SYSTEMATIC HISTORY.

Crambus laqueatellus was first described by Clemens in 1860. Walker redescribed it in 1863 from specimens from "North America" as *C. semifusellus*, a name reduced to synonomy in 1891 by Smith. Aside from its inclusion in various lists and the few references to it as an economic species its literature is meager. Fernald (1896) and Holland (1903) both figure the moth in colors. Nothing has ever been written about any stages other than the adult, except Felt's (1894) description of the egg and first stage larva. In other respects also his notes are hitherto the most extensive of any relating to this species.

DISTRIBUTION.

It is a North American species and occurs throughout a section of the United States extending from Maine to Texas and from Louisiana and Tennessee on the south to Colorado and southern Minnesota on the north. The writer has seen specimens from nearly every state within this area. The Texas record is based on Zeller (1872) who received specimens, presumably from Bosque County, collected by Boll. Fyles (1896) records it from Montreal and Quebec, Zeller (1863), Lintner (1874) and Felt (1894) list it from New York State, and Fernald (1896) from Maine and Louisiana. As indicated by Fyles' records, the species extends somewhat into Canada, but it does not appear in Allen's (1918) list of Nova Scotian

Crambinæ. The shaded portion of the accompanying map (Fig. I) indicates at a glance the territory from which *laqueatellus* has been reported but more extensive collections will likely somewhat extend these limits.

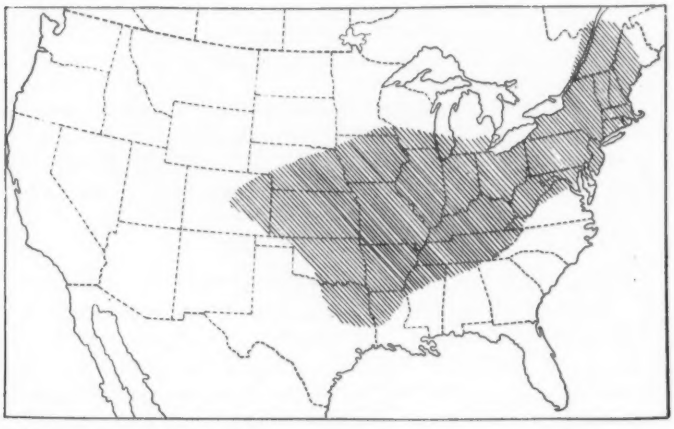

FIG. I.

SEASONAL HISTORY.

Crambus laqueatellus has one distinct generation annually. In Tennessee, where the appearance of the moths has been closely watched for several years, the period during which they have been found in the field extends from April 24 to May 31. Farther north they appear correspondingly later. Felt (1894) states that this is the earliest species to appear in New York State and that at Ithaca it has a compact breeding season of about five weeks. His trap light record for 1889 shows that at Ithaca specimens were taken from May 26 to June 17. According to Webster (1896) moths were abundant in northern Ohio in 1881 from May 29 to June 17. At Columbus, Ohio, Hine (1897) records the moths as present the latter part of April and through May. In Smith's (1900) New Jersey list the species is recorded for May, June and August. August is included on the basis of a single moth taken on the 31st. This record and one by Gillette (1898) mentioning the capture

of a specimen at light at Denver, Colo., on August 16, seem to indicate that there is a slight tendency toward a second generation. This is corroborated by the results of our rearing experiments, reported in more detail later, where moths matured in September from eggs laid the previous May. In general, however, it may be assumed that there is but a single annual generation, the period during which the moths are present in any given locality covering about five weeks. The following table gives the dates within which the moths have been recorded in the respective states.

Illinois—May 14–May 28.
Iowa—June 6–June 16.
Kentucky—May 23–June 21.
Maryland—May 8–May 28.
Michigan—June 6–June 14.
Minnesota—June 6.
New Hampshire—June 2.
New Jersey—May 18–June 24.
New York—May 20–June 24.
Ohio—June 9.
Pennsylvania—June 14–June 30.
Tennessee—April 24–May 31.
Wisconsin—June 15.
District of Columbia—May 20.

This list is very incomplete, but will serve as a starting point for further observations.

The larvæ have never been taken in the field and nothing is known of their seasonal habits. Judging from others of this genus it may be predicted that the larvæ feed and grow during the late spring and summer, reach their growth by the end of the summer season and then remain quiescent in their cocoons during the winter, pupating ten days or two weeks before their emergence in the spring. Whether they feed at all in the spring or complete their growth in the fall is a fact that will have to be ascertained by further studies.

ECONOMIC HISTORY.

Unless further observations bring to light something entirely new in the economy of this species, it must be listed as of little or no economic importance. It has once been charged with injury but it seems certain that it was a case of mistaken identity or bad companions. F. M. Webster (1896) found the moths abundant in association with those of *Crambus trisectus* and *C. mutabilis* a short time after crambid larvæ had devastated fields of grass and small grain in northern Ohio in 1896. While *laqueatellus* larvæ, if present in numbers, might somewhat intensify the damage in such a case, it is very much more probable that the injury should be laid to the other two species,

both of which have repeatedly proved themselves capable of becoming pests of considerable importance. No adults were reared directly from the larvæ which caused the Ohio damage. Runner (1914) lists this species as of economic importance, but apparently bases his statement on the foregoing record and furnishes no additional evidence. Felt (1906) also blackens its character on the same flimsy basis, but until new evidence can be produced the verdict must be "not guilty."

HABITS OF THE MOTHS.

In Tennessee the moths have been found only on lands which have been devoted to grass for some years, such as parks, permanent pastures and meadows. They occur on rolling, well-drained, and sometimes rather damp land, either open or with scattering large trees, but never on high or dry knolls. They do not appear to be generally distributed over a district, but seem closely confined to certain small areas varying in size from a few yards to two or three acres. During the early part of their season no moths occur outside these areas, but toward the close of their period of flight they become somewhat more diffused. Observations show that these infested areas remain the same from year to year. For some time no explanation could be offered for this fact but when it was found that the larvæ, especially in the early stages, can subsist only on certain mosses, it appears that the presence of these essential food plants is the factor determining both the abundance and exact distribution of the species.

The moths are easily flushed at any time of day, fly in a rather direct line for four to ten yards and alight abruptly, always head up, sometimes on a broad-leaved plant, but preferably on a grass stem. When blue grass is present they often choose its more or less pendulous heads and when so resting are very inconspicuous. Occasionally moths which have been flushed several times will feign death and often when struck down with a net they remain motionless until touched.

In our collections the males greatly predominate, especially at the first appearance of the moths. Apparently the males emerge somewhat earlier than the females and the following

record of moths taken at Nashville in 1916 by Mr. W. B. Cartwright bears this out:

Date Taken	Total Moths	Male	Female
May 5	10	10	...
May 6	38	32	6
May 8	43	30	13

Of the 38 specimens taken in the field in 1914, 22 were males; of the 118 taken in 1915, 101 were males, and of 94 taken in 1919, 75 were males. Of the total taken in the three years, 79% were males. Felt's (1894) record shows that in 1889 at Ithaca, N. Y., 55 moths were captured in a lantern trap, 26 of them males and 28 females, this being the only one of all the species which he worked where the females captured at light exceeded the males. In our work no trap lights have been operated near where these moths were known to occur. None were taken at light at Nashville, and but one, a male, at Knoxville. We have been unable to verify Felt's statement that the females fly later in the day than the males.

The adults of both sexes are vigorous and live longer in confinement than those of most species. Eighty-four males collected on various dates lived on the average 4.7 days confined in dry 2-dram vials; 21 females under the same conditions averaged 5.8 days. In the open, under normal conditions, the moths of both sexes probably live much longer than this. The sexes are more nearly equal in their vitality than is usual in this group, for in confinement the males of other species usually die very much sooner than the females. One male lived 11 days, which is longer than any female survived.

The great vitality of these moths is also displayed by the fecundity of the females. Felt states that the species is prolific and we have found this to be true, in fact, this is the most prolific species in this genus of which we have any knowledge. His record of "over two hundred" eggs was far surpassed. One moth laid 868 eggs, the largest number obtained from any individual of any species of this genus so far. Others laid 832, and 720, and eight laid over 500 each. The average for

25 moths under observation was 378, an average of 65 eggs per day for the life of the average female. Our records show that the largest number of eggs was deposited usually the first or second night after capture with a gradual decrease in number nightly until the death of the moth. The largest number laid by one moth in one night was 455, but records of 250 were several times obtained. All these moths were confined in dry vials and undoubtedly died somewhat sooner than they would have done under natural conditions, but from results obtained in more extensive experiments with other species it is concluded that the total number of eggs produced would not have materially increased with lengthened life.

The moths follow the usual habit of the genus in dropping their eggs promiscuously while in flight, but it seems that they are not so careful to await nightfall before beginning operations as are many of the other species. Females captured late in the afternoon sometimes dropped several eggs within a few minutes of their capture.

The larvæ.—In the first two years of work with this species we were entirely unsuccessful in rearing the larvæ. Great numbers of active, newly-hatched larvæ were placed in the small tin boxes used for rearing other species and supplied with fresh leaves of bluegrass, red and white clover, alfalfa, soy bean, cow pea, wheat, rye, corn, timothy, orchard grass, *Muhlenbergia diffusa*, *Plantaga lanceolata* and *Rumex crispus*, all of which they consistently refused to touch. Numbers of larvæ were transferred to potted plants of corn, rye, oats and bluegrass, but later no trace of their having fed could be found. The flora of the various tracts frequented by the moths was minutely studied in an effort to find some plant common to them all. In several such places the stand was apparently pure bluegrass. No empty cocoons or pupal shells were found by digging about plants where the moths were active. Numerous crambid larvæ collected from various places were reared, but none developed into moths of this species.

In the spring of 1916, however, acting on a clue gained from another species, some of the larvæ were put into a box containing among other things, a bit of moss. It was seen almost at once that the larvæ were attracted to the moss. They fed on it to some extent and one or two of the larvæ prepared

to molt to the second instar. None succeeded, however, and all finally died.

The next year the test was repeated, using moss of several different species. The larvæ fed to a slight extent on several of them, but throve and finally matured on only one, ***Thuidium delicatulum*** (L.) Mitt. It is very likely that other species are equally as acceptable as this one. After the first instar leaves of bluegrass, corn, cow peas and crabgrass were offered them frequently and as they grew older some of the larvæ fed to a greater or less extent but without showing any marked preference. They continued at the same time to feed on the moss and some of them reached maturity without other food. It was plainly evident that moss is absolutely essential to the young larvæ, as we never succeeded in getting them beyond the first instar without it. In the later instars their appetites are a little more elastic, but even then they do not appear to thrive as well on a diet limited to grasses as when they have a little moss for an appetizer.

As stated above, nothing is known of the behavior of the larvæ in the field for they have never been found under natural conditions. After it was found that they would feed and thrive on moss a number were reared from egg to adult in individual tin boxes. Instar records of some were kept but because of the small number for which the data are complete it is not possible to draw reliable conclusions. It is not easy to get accurate instar records of this species because each larva makes for itself a silken tube or retreat running through the moss mass. To search out and examine the larvæ daily to determine their condition results in the death of most and the abnormal development of the rest. Suffice it to say for the present that larvæ obtained from eggs laid May 17, developed into moths, part of which emerged in the rearing boxes between September 21 and 26. Others were apparently full grown and some in the pupa stage when exposure to an unusually severe frost on November 28, killed them all. The fact that there was such a variation in the period of development in this material showed that the results could only suggest and not prove the usual progress of events. It is evident that it is a very rare occurrence for moths of this species to appear in the fall. In several years collecting we have not known

such a case and the only recorded instances are those reported above from New Jersey and Colorado.

The egg.—The eggs when first laid are clear ivory-white. They hatch in 9 to 12 days, depending on the temperature. In one lot of eggs closely observed during the 12 days required for incubation, it was noted that after one day they had become flesh-colored, in two a pale salmon, which, during the third and fourth days slowly deepened to a rich salmon-red and then remained constant until the eleventh day. On the seventh day two small dark eye spots become faintly visible toward one end of the egg, by the eighth day they had become more apparent as small black points within the egg and remained thus until the egg darkened just before hatching. On the eleventh day the head and cervical plate were apparent, the former as a dark area nearly at the end of the egg and the latter as a transverse band close behind it. The dark color of these parts gave a purplish tinge to the whole mass of eggs. On the twelfth day the young larva emerged, effecting escape through an irregularly cut hole at one side of the larger end of the egg. The hole is just at the position on the egg occupied by the head of the larva before hatching, its edge not quite reaching the pole. In this species, as in several others, the egg shell consumed by the larva in effecting its escape from the egg changed to a bright red or orange in the intestinal tract, passed through as a solid plug and was voided as a brightly colored particle just in advance of the first excrement. The empty egg shell is pearly white with an irridescent lustre.

Infertile eggs do not change color and soon shrivel. Some eggs color slightly and then shrivel, indicating that they lack the vitality to develop even though they seem to be fertile. As a rule nearly all eggs hatch, only the last few deposited before the death of the moth being weak or infertile. This leads to the conclusion that the female moths mate but once and from observations on other species this probably takes place shortly after emergence from the pupa.

The pupa.—Nothing definite can be said about the cocoon or pupa. The few that were formed in the breeding boxes were enclosed in cocoons of silk and debris with nothing to differentiate them from those of other species.

DESCRIPTIONS.

The egg. Ivory-white, elongate oval, bluntly rounded on both ends, one of which is only slightly the larger, with about 16 longitudinal ribs merging at each end into an irregularly tuberculate polar area, these ribs and the intervals between them crossed by other less prominent ridges of which there are about 18 in the length of the egg. Measurements (10 eggs measured):

	Maximum	Minimum	Average
Length	.4413 mm.	.4060 mm.	.4130 mm.
Width	.3001 mm.	.2648 mm.	.2718 mm.

The larva. Instar I. (Newly hatched). Length 1.15 mm. Head width .1589 mm. Head deep fuscous to black, cervical plate fuscous, body pale orange, the color heightened by the red color of the particle of ingested egg-shell, paler caudad. Head and body with numerous pale slender hairs, those on body arising from small dusky pinacula.

II. Length 1.40, head width .2294 mm. Head black, cervical plate deep fuscous, body reddish brown with a greenish tinge.

III. Length 2.80, head width .3353 mm. Head dark yellow, semi-transparent, unmarked, shining, ocellar area black; cervical plate fuscous, shining, darker than the head; body pale green prominently marked with transverse segmental bands of reddish brown overcolor giving the entire insect a dingy brownish color.

IV. Length 3.5, head width .4235 mm. No marked change.

V. Length 5.9, head width .5118 mm. Head clear dingy yellow, unmarked, ocellar area and narrow lateral margin black; cervical plate transparent, dusky greenish-brown with two or three dusky spots laterally; body reddish brown, pinacula fairly distinct especially on the thorax, somewhat darker than skin and rugose but not sharply defined, moderate in size. Setæ pale and shining.

VI. Length 7.0, head width .7415 mm. Head clear amber-yellow, mouth parts brown, ocellar area and marginal line black; cervical plate glassy, transparent and colorless except for the greenish color from food, a dusky spot toward either end; pinacula prominent, rugulose and chocolate-brown, rather large; skin finely granular, glistening, covered especially caudad with reddish-brown or maroon overcolor through which are small groups of small clear vacuoles along the lateral margin. At a glance the larva appears dark reddish-brown with a clear yellow head.

VII. Length 10.0, head width .9794 mm. Head clear yellow with a row of small dusky points across the face, ocellar area marginal spot and line and mouth parts black; cervical plate transparent, greenish-yellow; body heavily covered with reddish-brown overcolor in which are rows of small clear vacuoles along the dorsolateral margin; skin dull, pinacula feebly shining and rugulose, poorly defined and indicated only by the character of the surface, body paler caudad.

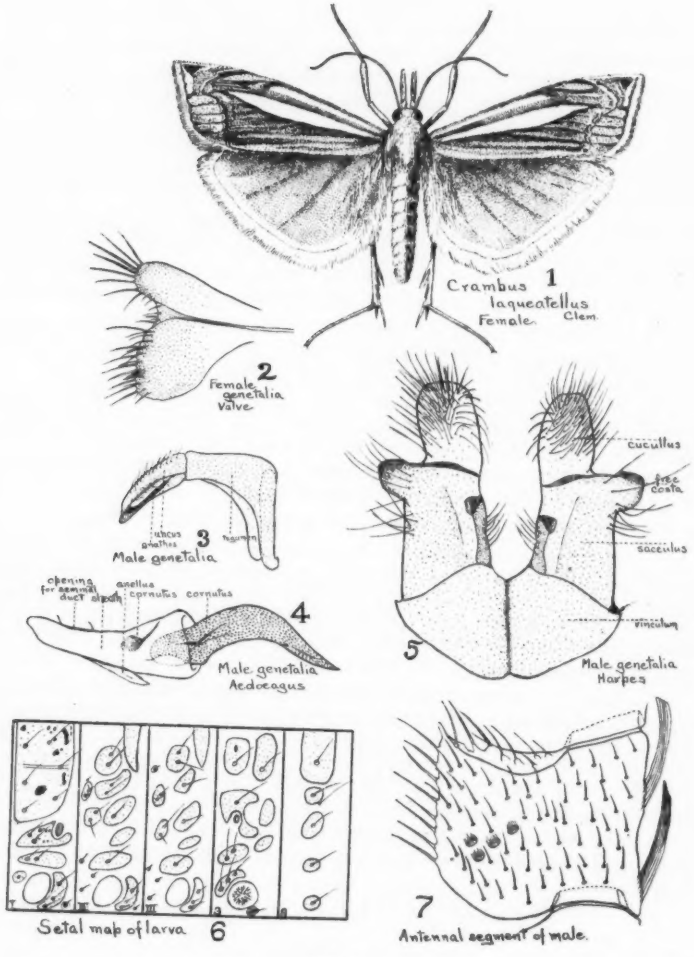
Crambus laqueatellus Clem. Female
1
Female genetalia Valve
2
Male genetalia
3
Male genetalia Aedoeagus
4
cucullus
costa
sacculus
Male genetalia Harpes
5
Setal map of larva
6
Antennal segment of male.
7

FIG. II.

VIII. Length 14.0, head width 1.2126 mm. Head clear pale yellow; cervical plate transparent with dusky cephalic margin; skin of thorax pale yellow, of abdomen deeply covered with purplish-brown overcolor against which the chocolate-brown pinacula are distinguishable only by the texture of their surface.

IX. Length 15.0, head width 1.4929 mm. Head yellow with a slight brownish tinge and a very faint brownish pattern, clypeus whitish, rest of mouth parts dark brown; ocellar area and marginal spot black; cervical plate clear greenish-yellow with an oval fuscous spot near each end; body color dusky green, darker caudad with the dense dark purple overcolor through which on the caudal two-thirds of the body there are conspicuous rows of large clear vacuoles along the lateral and segmental lines; skin granular, pinacula large, dark purple, shining and feebly rugose; caudal plate dusky with dark points. For relative size and arrangement of the pinacula see (Fig. II, 6.(

The pupa. Length 9.0 mm., width 2.8 mm. Dusky yellow, of the usual pyralid shape. Spiracles small but sharply elevated. Cremaster broad, flattened, from above subquadrate, somewhat narrowed caudad with a minute pale seta at each outward angle, the tip narrowed and abruptly depressed, almost tubercle-like, bearing at its extremity a pair of larger dark setæ; lateral grooves shallower and narrower than in most species, only moderately curved; beneath excavated.

The adult. The following is Clemens' (1860) original description slightly modified by Fernald (1896). (Fig. II, 1.)

"Expanse of wings 23 mm. Head luteous; thorax and palpi fuscous, the latter whitish beneath. Fore wings ochreous, with two silvery-white streaks separated by a fuscous streak; the outer silvery streak margined on costa with fuscous; the inner one, which extends beyond the apical third, edged on the fold with fuscous. Beneath the fold the wing is pale yellowish with fuscous streaks along the submedian veins. Apex of the wing tinted with ochreous yellow, the veins streaked with silvery white; on the costa near the tip an oblique silvery streak, margined on both sides with fuscous. The subterminal silvery-white line much angulated, bending in below the apex, leaving a large whitish marginal patch streaked with dark parallel lines which end in dots before the terminal line. Fringes lustrous ochreous. Hind wings pale fuscous; fringes white."

The Tennessee specimens agree well with this description but are somewhat larger, averaging 27 mm. in alar expanse. The "whitish marginal patch" is more pale fuscous than white and the "pale fuscous" hind wings are whitish along the margins especially toward the apex.

Genitalia. Female. (Fig. II, 2). Anal plate wider than long, somewhat constricted at base, margins serrate with tubercles terminating in long stout spines; the upper third sharply rounded and separated from the rest by a deep rounded notch, lower lobe shorter than the upper, evenly rounded above, slightly angled at lower corner. *Male.* Tegumen (Pl. XII, Fig. 3) with both body and limbs rather narrow and about equal in length the latter slightly narrowed mesad, and rounded

distad. Uncus setigerous, stout, narrowing acutely distad and tipped with a short sharp curved tooth; gnathos naked, slender, exceeding the uncus, at tip widening and the margins upturned forming a pocket into which the tip of uncus fits when closed. Harpes (Fig. II, 5) broad at base, the costa of the harpes proper free but greatly reduced to chitinized angular lobe extending at right angles to the base of the cucullus which is a broad rounded, lightly chitinized process, hairy within and separated from the sacculus by a narrow chitinized carina. Sacculus broad and almost rectangular, slightly concave, sparingly setigerous on both margins with a portion of the inner margin thickened and inturned and terminating in a small rounded lobe. Vinculum a broad subtriangular, weakly chitinized area supporting the sacculi. Aedoeagus (Fig. II, 4) subconical, smaller and rounded at the base, flaring somewhat at the open end, very feebly chitinized, bearing inside about midway a small acute chitinous spine with a broad flat base, and just within the open end and projecting far beyond a huge, heavily chitinized curved, flattened spine longitudinally carinate at the base and covered with minute acute points inclined toward the tip, this spine or cornutus equalling in length the aedoeagus proper. The anellus is a mere membrane attached to the aedoeagus ventrad.

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*Because of the trivial nature of so many of the references it has been decided unwise to continue the plan outlined in the first paper of this series (Ann. Ent. Soc. Am. 11:51, 1918) and only literature referred to in the text is included in this bibliography.

A REVIEW OF THE DESERT LEAFHOPPERS OF THE ORGERINI (RHYNCHOTA FULGORIDAE).

By E. D. Ball and Albert Hartzell.

Stal[1] in 1859, figured and described *Orgerius rhyparus* from material collected at San Francisco and for many years the relation of this species to the other members of the group remained an unsettled question. About ten years ago it chanced to be the good fortune of the senior writer while collecting Homoptera in California to rediscover Stal's species and secure sufficient material to throw some light on the interpretation of the characters and classification of this aberrant and interesting tribe of Fulgoridæ. Collections were made covering Oregon, Idaho, Utah, Nevada, California and Lower California, Mexico.

The adults of the Orgerini are wingless with brachypterous elytra and resemble the nymphs of winged species. They present a grotesque and unusual appearance in that they assume an upright position in walking on their long, slender legs; their short, stout bodies and their long, pointed cephalic processes together with a peculiar strut in locomotion give the insects a unique place among Nature's odd creatures. The rostrum is remarkably long, in some of the more upright species, exceeding the abdomen and instead of carrying it inclined forward as most leafhoppers do in feeding these insects feed with the rostrum running down the abdomen and extending beyond into the plant tissue. These odd adaptations seem to fit the insects to the hot, dry inhospitable desert regions of the Southwest and apparently is an arrangement to lift the body from the burning heat of the sands. Among the host plants recorded for the various species are some of the more common xerophytic vegetation such as Mormon tea, sage brush, tree Yucca and chaparall.

In 1909, the senior[2] writer published an account of some of the material he collected from this region proposing the genera *Timodema* and *Orgamara* with a number of new species. In 1913, Oshanin[3] published a synopsis of the tribe *Orgerini* of the

[1] Freg. Eugen. Resa. Ins., p. 274, 1859.
[2] Ball, E. D., Proc. Bio. Soc. Wash., Vol. 12, pp. 197-204, Dec., 1909.
[3] Oshanin, B. F., Insecta Hemiptera, Vol. 3, part 1, pp. 1-113, 1913.

Russian fauna. This was followed in the same year by a resume[4] in German with the keys translated in Latin. It appears from the keys and descriptions that he has misinterpreted the character of the genus *Orgerius* as he describes it as wanting a callosity behind the eye while he erects the genus *Nymphorgerius* for species with short angular vertices and the eyes bearing posterior callosities. Stal's figure of *Orgerius* shows distinct callosities behind the eyes and our material also exhibits this character. Unfortunately, Oshanin had no American material for comparison and it is very unlikely that the genus *Orgerius* is represented in Europe. As some of the European genera appear to be closely related to our American genera we have attempted to state the differences here.

The genus *Sphenocratus* Horv. superficially resembles *Deserta* but differs from the known American genera in lacking ocelli. *Nymphorgerius* Oshanin resembles the true *Orgerius* but has the antennæ placed in a large pit with the margins elevated into a carina. Unless we misinterpret this character none of the known species in North America possess this peculiarity. *Haumavarga* Oshanin differs from all known American genera of this tribe in lacking a median carina on both vertex and pronotum. It bears no superficial resemblance to any of our species as the vertex is much broader and the angles very much rounded. *Repetekia* Oshanin has the anterior femora and tibia flattened as in *Timodema* Ball but has the median carina of the front divided by an obtuse fracture. *Timodema* in addition has the middle femora and tibia foliaceous. *Ototettix* Oshanin resembles *Timonidia* but has a distinctly different front resembling that of *Ticidia* Uhl. but may be separated from the latter genus by its broad head which is upturned at an angle of about 45°, while *Ticidia* and *Timonidia* have the head normal; also the species of *Ototettix* are not banded as are the species of *Ticidia* and *Timodema*. *Tigrahauda* Oshanin resembles *Acinaca* in the shape of the cephalic process but differs in having the oblique carina running parallel to the ventral margin of the cepahlic process while in *Acinaca* the oblique carina curves abruptly upwards and ends on the dorsum. It also differs from *Acinaca* in having the vertex furrowed and wanting a median carina.

[4] Oshanin, B. F., Rev. Rus. Ent. Vol. 13, No. 1, pp. 135-147, 1913.

KEY TO THE N. A. GENERA OF ORGERINI.

A. Callosity behind eye; vertex elongate or angulate.
  B. Vertex elongate, with more than one-half its length beyond the eyes.
    C. Cephalic process truncate at the extremity. Five-angled.
      D. Cephalic process gradually tapering as seen from both top and side. Apex small.....*Orgamara* Ball.
      DD. Cephalic process parallel margined; apex as seen from the side slightly enlarged; projecting at an angle with vertex.....*Yucanda* nov. gen.
    CC. Cephalic process as seen from side, beak-like, the apex obliquely rounding from above, the lower angle slightly produced.....*Deserta* nov. gen.
  BB. Vertex angulate, narrowing from the eyes, less than twice the length of the eye.....*Orgerius* Stal.
AA. No callosity behind eye; head rounding or if elongate, broad, if seen from the side.
    E. Vertex angulate, produced in front of the eyes at least one-third its length.
      F. Head twice the length of the eye as seen from the side, widening toward the truncate apex.....*Acinaca* nov. gen.
      FF. Eyes contigious to pronotum; head distinctly less than twice the length of the eyes; as seen from the side, distinctly narrowing and roundingly truncate.....*Aridia* nov. gen.
    EE. Vertex broad and short, scarcely longer than its basal width. The lateral carina of the front closely margins the eye clear to its juncture with the lateral margin of the vertex.
      G. Fore and middle tibia broadly foliaceous.....*Timodema* Ball.
      GG. Tibia normal.
        H. Lateral carinæ of the frontal tablet uniting some distance below the apex of the head.....*Ticidia* Uhl.
        HH. Lateral carinæ of the frontal tablet narrowing but not uniting before joining the vertex.....*Timonidia* nov. gen.

Orgamara Ball.

Resembling *Orgerius* Stal but with the vertex produced into a long stylate process, similar to that found in *Scolops*, but stouter.

Cephalic process long, tapering, nearly twice the length of the eye, truncate apically, but slightly inclined to the plane of the vertex. Front straight in profile, tricarinate, the lateral carinæ narrowing near the apex but not uniting with the median. The carina from the lower corner of the eye running obliquely to the upper margin of the snout at or beyond the middle; below this carina, the front is pustulate. A transverse carina sets off the posterior third of the vertex; median carina of the vertex extending onto the cephalic process a slight distance. Eye separated from the pronotum by an elongate callosity. Pronotum with a central raised tablet, tricarinate, the lateral extensions sloping strongly downward and backward, pustulate. Elytra covering the second segment of the abdomen, irregularly reticulate; a row of pustules near the posterior border of each segment. Legs long, slender, terete; hind tibia with 5–6 weak spines. Rostrum about equalling the abdomen.

Type of the genus *O. acuta* Ball.

This genus as now restricted, with *acuta* Ball as type, includes two species known only from Southern California and Lower California, Mexico. The slender tapering cephalic process will at once separate them from other groups.

Key to the Species of Orgamara.

A. Cephalic process long and slender, nearly twice as long as the eye; the anterior tablet of the vertex longer than wide.....*acuta* Ball
AA. Cephalic process broader and shorter, extending beyond the eye, but little more than its length; anterior tablet of vertex rectangular..*reducta* Ball

Orgamara acuta Ball.

(Plate XII, Figs. 12, 14, 16.)

Orgamara acuta Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 198, Dec., 1909.

A short-winged, dark fuscous species with an extremely long and slender cephalic process. Length 5–6 mm.

Cephalic process long and slender more than twice as long as the eye. The oblique carina meeting the margin of the cephalic process about one-third the distance from the apex. Anterior tablet of the vertex slightly longer than wide. The front narrow, elongate, over one-half its length beyond the median line of the eyes.

Color—Brownish fuscous, pronotum much lighter than scutellum. Irregular reticulations on the elytra and about four irregular stripes on the abdomen, lighter. Whole insect with a coppery reflection along the median line. Face uniformly brown.

This species is strikingly distinct from all others in the group and may be recognized by its long, slender, pointed cephalic process. Specimens are at hand from the region of San Diego, California, and adjacent portions of Mexico. Solitary individuals have been taken from the middle of June until early August. They occur in open spaces in the chaparall, two of them were beaten from *Arctostaphylos* but this may have been accidental.

Orgamara reducta Ball.

Orgamara reducta Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 198, Dec., 1909.

Resembling O. acuta, slightly smaller, paler, with a shorter cephalic process. Length 4 mm.

Cephalic process broad, less than one and one-half times the length of the eye. Oblique carina meeting the dorsum at the middle. Front broader and shorter than in *acuta*, the median line of the eye bisecting its length.

Color—Pale gray, mottled with fuscous. The carinæ on the vertex, the central plate of the pronotum, most of the elytra reticulations and four interrupted stripes on the abdomen creamy white. Front pale, slightly sprinkled with fuscous.

The stouter, lighter appearance and the shorter cephalic process will at once separate this species from *acuta*. Specimens are at hand from the Salton Sink region of California, taken late in June.

Yucanda nov. gen.

Cephalic process long, more than three times the length of the eye, parallel margined as seen from the side, curving upwards at an angle slightly less than 45°, widening toward the truncate tip, where it is five-angled. Front of equal width throughout, tricarinate, the lateral carinæ widening and the median carina elevated toward the apex of the cephalic process. Oblique carina extending two-thirds the length of the cephalic process, pustulate below. Pronotum narrow, pustulate, median tablet not differentiated. Eye separated from scutellum by an elongate callosity. Anterior tablet of scutellum raised, tricarinate, lateral projections pustulate. Elytra abbreviated, irregularly reticulate. Abdomen long, oval, obese. Rostrum definitely exceeds the abdomen. Legs long, slender; hind tibia with 4–5 weak spines.

This genus is readily distinguished from Orgamara by its curved and apically truncate cephalic process.

Type of genus *Orgamara albida* Ball.

Yucanda albida Ball.

(Plate XII, Figs. 2, 7.)

Orgamara albida Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 200, Dec., 1909.

A large globose creamy yellow species with a long curved cephalic process. Length 6–7 mm.

Structure of the genus, pale creamy yellow, the eyes, lateral carinæ, the antennæ, fore and middle tibia and the tip of the rostrum brownish.

This strikingly distinct species in both color and structure lives, both nymph and adult, upon the tree Yucca (*Yucca baccata*) of the Mojava desert region. These insects hide between the bases of the sword-like leaves where they are practically inaccessible except to vigorous beating with a heavy club. Adults were abundant together with a few large larvæ June 15 indicating that a brood was just maturing, while on another visit July 30 but one or two old adults could be found.

Deserta nov. gen.

Intermediate between *Yucanda* and *Orgamara* but with the apex of the cephalic process beaked.

Cephalic process moderately long, very nearly parallel margined to just before the apex where it rounds over to the acute and slightly pro-

duced lower angle which is curved down like the beak of a raptorial bird, the extremity triangular. Front broad and nearly parallel, the lateral carinæ widening toward the apex. Median carina of vertex extending the full length of the cephalic process. Central tablet of pronotum distinct. A definite oval or slightly oblique callosity behind the eye, separating it from the pronotum. The elytra brachypterous, irregularly reticulate. Legs simple; hind tibia with 7 strong spines.

Type of the genus *Orgamara bipunctata* Ball.

This group is distributed from southern Idaho to Mexico between the Wasatch and Sierra Nevada Mountains and extending across the latter range in Southern California. All the species of this group have been taken from sage brush regions and most of them have been beaten directly from species of *Artemesia*.

Key to the Species of Deserta.

A. Part of the front above the center of the eyes twice as long as that below.
  B. Cephalic process as seen from above extending beyond eye less than twice the length of the eye. Lower angle of anal tube of male more than one and one-half times the dorsal length of the tube, broadly expanded and curved down to meet the long, narrow plates. *obscura* Ball
  BB. Cephalic process more than twice as long as the eye. Lower angle of anal tube of male narrower and less produced.....*bipunctata* Ball
AA. Part of the front above the center of the eyes equalling that below. *obesa* Ball

Deserta obscura Ball.

(Plate XII, Figs. 4, 11.)

Orgamara obscura Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 200, Dec., 1909.

Resembling *bipunctata*, darker with a shorter cephalic process. Length, females, 6 mm.; males, 5 mm. Ashy gray with a curved and slightly hooked process.

Cephalic process shorter and stouter than in *bipunctata*. Front with the median tablet expanded before the apex, rounding above. Part above the center of the eyes one-half longer than that below. Color—white, finely sprinkled with dark points, giving the insect an ashy gray appearance. Front greenish, the clypeus rusty orange.

Genitalia.—Lower half of anal tube in the male extended over one and one-half times the median length of the tube, broadly expanded and curved down to meet the margins of the long, narrow plates. Surface of the lower half furrowed and covered with coarse hairs.

This species has been taken on sage brush (*Artemesia tridentata*) at Nampa, Idaho, Wells, Nevada, Marysvale and Chadburn's, Utah, and Doyle and Chilcoot, California. Collections have been made all around this area, without finding the

species; it therefore appears to be confined to the State of Nevada and a narrow fringe of the adjoining states and only on the higher levels where sage brush grows. Nymphs and adults were found during July at the lower levels, adults were nearly all out by July 20 but in the mountains nymphs were still present up to early August, while adults were taken up until the last of the month.

Deserta bipunctata Ball.

Orgamara bipunctata Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 199, Dec., 1909.

Resembling *obscura* but with a longer, slimmer, less inclined cephalic process about twice the length of the eye and lighter in color. Length, female, 6 mm.; male 5 mm.

Front with the central raised tablet distinctly narrowing before the eyes, then parallel margined to the clypeus. The part of the front above the center of the eyes almost double that below. Elytra shorter than in *obesa*, slightly abbreviated, truncate. Color—Variable, but usually a dull fuscous, finely irrorate with fuscous brown.

Examples are at hand from St. George, Utah, and Ravenna, California, probably on *A. tridentata*.

Deserta obesa Ball.

Orgamara obesa Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 199, Dec., 1909.

Resembling *bipunctata* but smaller with a shorter, blunter cephalic process upturned at a sharper angle, slightly less than 45°. Length, female, 6 mm.; male, 5 mm.

Cephalic process slightly more than once the length of the eye. Elytra short, the inner angles broadly rounding. Front parallel margined, part above eyes but little larger than that below.

Color—Pale straw, with a dirty orange cast. Nervures of the elytra with the cells smoky, the nervures of a pale straw color.

This species has been taken at American Fork and Parowan, Utah, from sage brush in July and August.

Orgerius Stal.

Resembling *Deserta*, but with a broader, shorter, distinctly triangular cephalic process.

Cephalic process short, broad at the base, tapering to an angular or slightly conical point, not truncate. The lateral carinæ of the front rounding into the median carina at the apex of the cephalic process. Oblique carina curving upwards from the eye, pustulate below; median carina extending to the apex. Eye separated from the pronotum by a diamond-shaped callosity. The anterior margin of the lateral tablets

of pronotum transverse instead of inclined posteriorly as in *Deserta*. Carinæ of scutellum sharply defined. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Rostrum equalling the abdomen. Anterior femora expanded three times the width of the tibia; post tibia flattened, inclined to be serrate, the serrations crowned with 6–8 black spines.

This genus was described by Stal for *O. rhyparus* from San Francisco. Oshanin, 1913, in a review of the group evidently misinterpreted the character of the genus as he describes *Orgerius* as wanting a callosity behind the eye, while he erects a new genus, *Nymphorgerius*, for species with short, angular vertices and the eyes bearing posterior callosities. He mentions a carina between the antenna and the eye, which is lacking or but feebly developed in our species and it is probable that the true *Orgerius* does not occur in Europe.

Key to the Species of Orgerius.

A. Size variable. Vertex narrow, one-half longer than its width; the hind tibia distinctly flattened basally, the heavy spines appearing as serrations. *O. rhyparus* Stal.

AA. Small, pale, vertex wider, less than one-half longer than its basal width. Posterior tibia not modified..... *O. minor* Ball

Orgerius rhyparus Stal.

Orgerius rhyparus Stal. Freg. Eugen. Resa. Ins., p. 274, 1859.

A large, obese, globose species with a long, acutely angular vertex extending one-half its length beyond the eye. Vertex long, parallel margined or widening near the base, then acutely angular, the apex slightly rounding, the lateral carinæ strongly foliaceous. Face in profile slightly dished, forming with the vertex an acute angle. Median tablet narrow, parallel margined, about equalling the width of the eye.

This species appears to be extremely variable in size and color and is best characterized under its varieties. It was described by Stal from specimens from San Francisco and has been found to extend from Oregon to Mexico, west of the Sierra Nevada range. The larvæ appear in May and June, the adults in June and July. They are found in bare places in dry, exposed situations.

Key to Varieties.

A. Large, obese forms, partly rufous or testaceous.
  B. Species entirely rufo-testaceous..... *var. rhyparus* Stal.
  BB. Rufous with elytra black..... *clitellus* n. var.
AA. Without reddish shade.
  C. Uniformly fuscous, size variable.
    D. Large, obese, females, 5 mm. or longer..... *concordus* n. var.
    DD. Small, females 4 mm. or less..... *pajaronius* n. var.
  CC. Uniformly pale or fuscous and pale, small..... *ventosus* n. var.

Variety **rhyparus** Stal.
(Plate XII, Fig. 15).

This variety is characterized by its rather uniform testaceous color and appears to be one of the rarer forms. It has been found in the foothills around the Sacramento and San Jauquin valleys and extending over the range towards the Salton Sink as far as Cabazon.

Variety **clitellus** n. var.

Resembling var. *rhyparus*, large, obese forms with a testaceous color sharply set off by the shining black elytra.

Described from three examples from Santa Margarita, Chico and Colfax, California. This variety was found with the preceding and appears to be a still rarer adaptation to these dry, hot situations.

Variety **concordus** n. var.

Large, obese form with the females averaging from 5–6 mm., uniform dull fuscous above, with a slightly pearl-gray sheen.

Described from two pairs from Cabazon, California, and Ti Juana, Mexico. This is the common variety in southern California extending from Visalia and Cabazon south and west to Ti Juana, Mexico.

Variety **pajaronius** n. var.

Small, rather slender, female not over 4 mm. in length, resembling *concordus* above but much smaller and with the face much more frequently transversely banded with light.

Described from two pairs from Salinas and Watsonville, California. This variety occurs on the Coast Range from the Salinas Valley north to San Francisco and a pair were taken on the eastern slope of the Sierra Nevadas near Le Grande, Oregon.

Variety **ventosus** n. var.

Resembling *pajaronius* in size and form, dimorphic in color, the female mottled fuscous and white, the central tablets of the pronotum and scutellum almost creamy, the face trifasciate with light. Male clear yellowish-white with a few fuscous spots on the lateral carinæ of the vertex.

Described from three pairs from Mojava, California, taken July 30. This peculiar form appears to be strictly confined to the sparse vegetation of that windy and inhospitable desert region. Most of the specimens were beaten from a low, spiny white shrub.

Orgerius minor Ball.

(Plate XII, Figs. 1, 6, 9.)

Orgerius minor Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling ***rhyparus*** but smaller, paler, with a shorter, broader vertex, two-thirds as wide as long, the foliaceous margins rounding into the blunt apex. Posterior tibia normal. Length 4.5 mm.

This species occurs in the desert region of southwestern Colorado and southern Utah, where it is found on the ground usually associated with some of the smaller salt bushes (*Atriplex* spp.).

Acinaca nov. gen.

Resembling *Yucanda* in structure, but with a very much smaller, shorter and more compressed cephalic process.

Cephalic process moderately long, strongly compressed, narrowing toward the apex; as seen from the side, flat and widens rapidly to a slightly rounding truncate apex, curving upwards, strongly inclined, much wider at apex than at base. The vertex is narrow, less than the width of the eye. The lateral carina of the face cuts the dorsum at one-third the distance to the apex. Median carina faint or wanting. Central tablet of front narrow, almost linear, tricarinate. No callosity behind eye, eye and pronotum widely separated. Pronotum very small, narrow, pustulate, the lateral extensions only represented by a narrow collar, a median but no lateral carinæ, without a raised central tablet. Scutellum very small, with a single carina. Elytra brachypterous irregularly reticulate. Pustules on abdominal segments large, prominent and extending only half way to the median line. Rostrum equalling the abdomen in length.

Type of the genus *Acinaca lurida* sp. nov.

This genus may be distinguished from any other of the group by its simiter-shaped cephalic process.

Acinaca lurida sp. nov.

(Plate XII, Figs. 8, 10.)

A small, globose, highly ornamented green and brown species with a compressed cephalic process. Length, females, 3 mm.; males, 2.5 mm.

Cephalic process slightly longer than the eye, roundingly truncate; its tip about five times as deep as wide. Vertex a narrow, slightly widening strip between the large round eyes. Dorsum of cephalic process long, triangular, equalling the vertex, inclined upwards at an angle of 45°. Front elongate, widening below the eyes which are slightly above the middle. Frontal tablet very narrow, almost linear, strongly

inflated just above the eyes. Pronotum scarcely more than half as long as the diameter of eye, sloping irregularly backwards to a mere collar. Scutellum very small without a defined tablet.

Color—Bright testaceous with the head and pronotum a bright green. A belt covering most of the elytra deepening anteriorly and encircling the insect below just back of antennæ, dark shining brown to black. The lateral carinæ, median carina of the front and the margins of the truncate cephalic process black-lined. Fore and middle tibia lineate with light.

Described from three pairs from Mojava, California, taken July 30, 1912. Other examples are at hand from Ravenna, California. This striking and easily recognized species was taken only on one of the chaparall bushes, *Eriogonum fasciculatum*, of the deserts and dry mountain slopes to which its color almost perfectly adapts it.

Aridia nov. gen.

Resembling *Acinaca*, but with a shorter, broader, more rounding cephalic process.

Cephalic process broad and short, rounding at the apex, slightly inclined upwards. Vertex broad, as wide as the eye, the median carina fades out before reaching the apex. Front narrow, with very sharply defined carinæ; median carina of the front uniting with the lateral carina in a five-sided figure. Frontal tablet linear, inflated just below the eyes. No callosity behind the eyes, the eye and pronotum contiguous. Pronotum short, with median carina, without a central tablet, pustulate. Scutellum with central tablet, with three sharply defined carinæ. Elytra brachypterous. Strongly reticulate. Abdomen ovate. Abdominal segments with a row of pustules along posterior margin two-thirds of the distance to the median line. Legs linear, not expanded.

Type of the genus *Orgerius compressus* Ball.

Key to the Species of Aridia.

A. Cephalic process upturned at an angle of about 45°. Rostrum about equalling the abdomen.....*A compressa* Ball

AA. Cephalic process flat or upturned but very slightly. Rostrum decidedly longer than abdomen.....*A. erecta* Ball

Aridia compressa Ball.

Orgerius compressus Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling *erecta*, but with a longer, narrower more upturned cephalic process. Length 4 mm.

Cephalic process upturned at an angle of about 45°, slightly less than the length of the eye, acutely angular with apex truncate. Front narrower than in *erecta*, sharply carinated. Line through center of eyes cutting slightly above the middle. Vertex long, angulate with faint

median carina, lateral carina more sharply defined. The lateral carinæ of the front rounding in and uniting with the median at the rather broad truncate apex, not joining the median carina of the vertex. Rostrum about equalling the abdomen. Grayish brown, abdomen smoky with a few irregular lines.

Examples are at hand from Helper and Marysvale, Utah, taken in July and August from sage brush (*Artemesia tridentata*) growing on the sunny slopes of the Wasatch Mountains at elevations of 7,000 to 8,000 feet.

Aridia erecta Ball.

(Plate XII, Fig. 3.)

Orgerius erectus Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling *Orgerius minor*, but smaller and with a rounding cephalic process very slightly upturned. Length, 4 mm.

Cephalic process short, extending beyond the eye less than its length, rounded at the apex with a truncate tip. Front sharply carinated, narrow, the width about one and one-half times the short diameter of the eye, lateral carinæ uniting with the median carina just before the truncate apex of head, median carina of the vertex not uniting with the median carina of the front. Vertex small, triangular, apex of the head as seen from side bluntly rounded, almost truncate, not curved upward as in *compressa*. Rostrum decidedly longer than abdomen. Pale smoky lined with brown; elytra dirty straw; abdominal segments smoky with irregular dark markings.

Examples are at hand from Reno, Nevada, Doyle, Chilcoot and Kelso, California, indicating a distribution for a long distance along the slopes of the Sierra Nevada Mountains. The larvæ were abundant in early June. Very few adults at low levels while they were about equally divided on the highest levels late in July. They were found on the ground in open places.

Timodema Ball.

Intermediate between *Aridia* and *Ticida* but with the anterior femur greatly expanded, foliaceous.

Cephalic process short, broad at the base, rounding at the apex, vertex tricarinate, shorter than eye, not extending to the apex of the head, with acutely angulate anterior margin, the median carina of the front uniting with the median carina of the vertex. Front broad, five carinate, median tablet tricarinate. Median carina of the front and cephalic process coalescing. Clypeus broad, distinctly tricarinate. No callosity between the eye and pronotum. Pronotum short without raised tablet, pustulate to the median carina. The central tablet of the

scutellum not pustulate, tricarinate. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Abdominal segments with distinct median carina. Fourth, 5th and 6th segments with a row of pustules along the posterior margin for a part of their length. Rostrum equalling the abdomen. Fore and middle femora and tibia greatly expanded, foliaceous, carinated; basal part of tibia leaf-like, tapering. Hind tibia with four spines.

Timodema miracula Ball.

(Plate XII, Fig. 17.)

Timodema miracula Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 201, Dec., 1909.

Resembling *Ticidia cingulata* Uhl. but with the anterior and middle legs foliaceous, slightly larger, broad and darker, pitchy brown or black with two white spots on the elytra. Length 3.5–4 mm.

Cephalic process appearing only as a rounding margin to the vertex, extending less than its width beyond the eye. Vertex shorter than eye, with indistinct median carina, anterior third angulate. The line uniting the frontal tablet with vertex equalling only one-half the length of the vertex. Front short and broad, not extending beyond the eyes. Fore and middle femora broadly foliaceous on both margins longitudinally carinated. Tibia broadly foliaceous at the base, rapidly narrowing to the rather attenuate apex.

Color—Dark brown or black with a transverse line on the scutellum, the posterior margin of the elytra and the tips of the fore and middle tibia milky white, and a transverse band on the fore and middle tibia reddish. A transverse band of white across the base of the clypeus.

Examples of this curious species have been found at Ravenna, Ontario, Pasadena and Tia Juana, California, and in Lower California, Mexico. They occur only on the slopes of the mountain sides and have been found under the dense green-brush (*Adenostoma fasciculatum*) so common in the chaparall of these slopes. The adults appear late in June on the lower slopes while the larvæ will be common above. A month later the adults will be appearing near the tops of the ridges. Even the youngest stages of the larvæ have the foliaceous legs and present a ludicrous appearance, somewhat resembling a crab as they strut about.

Ticidia Uhler.

Ticidia Uhl., Trans. Md. Acad. Sc. I, p. 143, 1891.
Loxophora Van Duzee, Proc. Acad. Nat. Sci., Phila., LIX, pp. 469, 472, 1908.

Resembling *Timodema* Ball but smaller, with the fore and middle tibia normal, linear, not foliaceous.

Cephalic process short, broad at the base, with a round apex, vertex short, as long as the eye, margins carinate. Front five carinate, with median tablet tricarinate, the lateral carinæ roundingly uniting before the apex of the vertex. Clypeus broad, tricarinate. The eye set into the curve of the pronotum, without callosity. Pronotum short, transverse, without median tablet, entirely pustulate. Central tablet of the scutellum broad, without pustules. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Abdominal segments with a row of pustules on the outer margin of the posterior two-thirds. Rostrum distinctly exceeding abdomen. Anterior and middle tibia linear, not foliaceous; hind tibia with 6–7 spines.

Type of the genus *Ticidia cingulata* Uhl.

Ticidia cingulata Uhl.

Ticidia cingulata Uhl., Trans. Md. Acad. Sc., I, p. 144, 1891.
Loxophora transversa Van Duzee, Proc. Acad. Nat. Sci., Phila., LIX, p. 473, 1908.

Resembling *Timodema miracula* but smaller and with the fore and middle tibia normal. A small oval species transversely banded with gray and white. Length, 3.5 mm.

Cephalic process short, extending only slightly in front of the curve of the eyes. Front broad, distinctly wider than the eye. The single carina above the frontal tablet nearly as long as the vertex. Vertex wider than long, not extending beyond the eyes, obtusely triangular, posterior third with a strongly carinated margin, median carina obscure or wanting. Legs normal, anterior and middle tibia not foliaceous.

Color—Ashy gray, transversely banded with fuscous and white as follows: A narrow light band across the scutellum, a broader one across the apical half of the elytra and a third across the apex of abdomen. There is a pitchy black band across the face just below the eyes, bordered below by an ivory white one.

This species is evidently widely distributed over the desert region of south Utah as it has been taken at various places from Moab to St. George, Utah. It also occurs in a number of situations in south California from Cabozon to Ravenna. In all cases it has been found strictly around open spaces in the desert regions. The only plant which occurs in all these locations is the bush atriplex (*A. Canescens*) and it has usually been found closely associated with this plant. Adults have been captured from June 10 in hot situations to August 10 in cooler ones.

Timonidia nov. gen.

Resembling *Ticidia*, but smaller with a larger and more sharply angled vertex and still wider front.

Cephalic process almost wanting. The apex of the vertex slightly exceeding the eyes. Vertex triangular clear to the base, median carina weak. Front broader than in *Timodema*, frontal tablet broad, scarcely elevated, parallel margined to just before the apex where the lateral carinæ round in and unite with the vertex. Clypeus broader than in *Timodema*. No callosity between the eye and pronotum. Pronotum short, without raised tablet, pustulate throughout. Central tablet of scutellum broadening posteriorly without pustules. Elytra brachypterous, irregularly reticulate. Abdomen oval, abruptly terminating posteriorly, almost truncate. Abdominal segments pustulate as in *Ticidia*. Fore and middle tibia and femora linear, not foliaceous or expanded. Hind tibia with 2–4 weak spines. Rostrum equalling the abdomen.

Type of the genus *Timonidia solitaria* sp. nov.

Timonidia solitaria sp. nov.

(Plate XII, Figs. 5, 13.)

A small, globose, creamy yellow species. Length, female, 3.5 mm.; male, 3 mm.

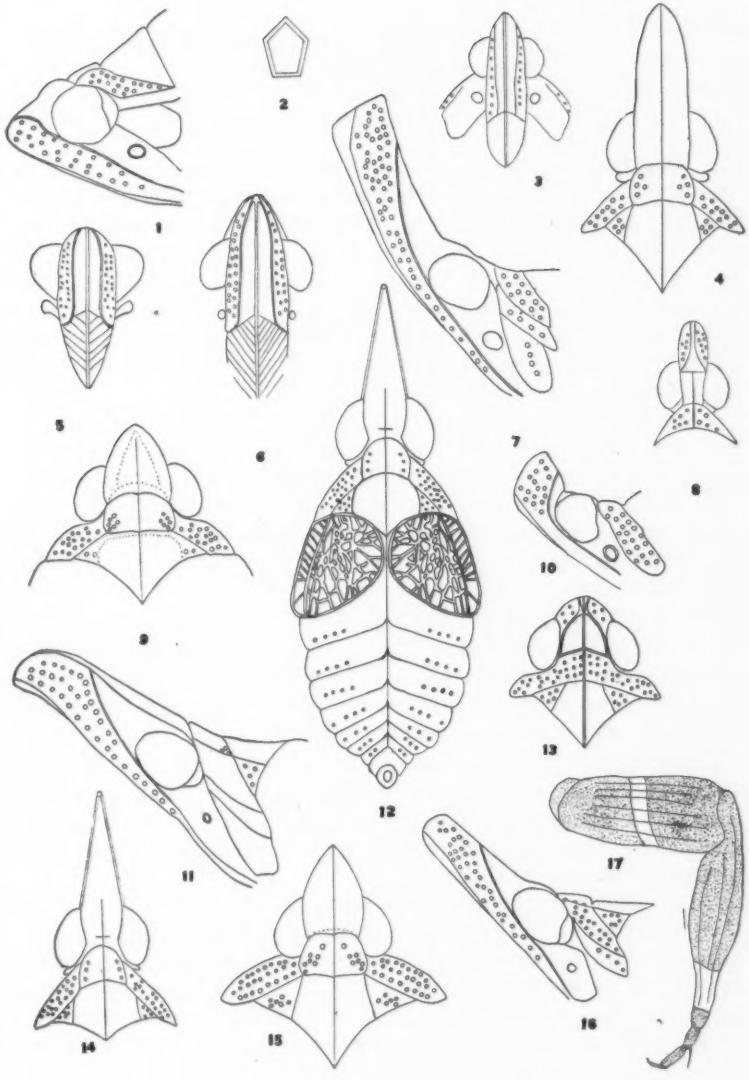
Structure of the genus, vertex short, about equal to the eyes. Roughly equilaterally triangular with the apex extending to the apex of the head where it joins the lateral carinæ of the front. Front broader than the width of the eye. Pale creamy yellow with a tawny tinge, eyes light brown.

Described from three examples from Mojava, California, taken July 30, on *Eriogonum fasciculatum* along with *Acinaca lurida*. This species superficially resembles *Orgerius rhyparus* var. *ventosus* but is quite distinct structurally. It is not well adapted to this plant in color and it is possible that this occurrence was accidental.

EXPLANATION OF PLATE XII.

The Figures of this plate were made with camera lucida by the junior author.

Fig. 1. *Orgerius minor* Ball, lateral view of head.
Fig. 2. *Yucanda albida* Ball, end of cephalic process.
Fig. 3. *Aridia erecta* Ball, front.
Fig. 4. *Deserta obscura* Ball, head, pronotum and scutellum.
Fig. 5. *Timonidia solitaria* sp. nov. front.
Fig. 6. *Orgerius minor* Ball, front.
Fig. 7. *Yucanda albida* Ball, lateral view of head.
Fig. 8. *Acinaca lurida* sp. nov., head, pronotum and scutellum.
Fig. 9. *Orgerius minor* Ball, head, pronotum and scutellum.
Fig. 10. *Acinaca lurida* sp. nov., lateral view of head.
Fig. 11. *Deserta obscura* Ball, lateral view of head.
Fig. 12. *Orgamara acuta* Ball, dorsal view without legs.
Fig. 13. *Timonidia solitaria* sp. nov., head, pronotum and scutellum.
Fig. 14. *Orgamara acuta* Ball, head, pronotum and scutellum.
Fig. 15. *Orgerius rhyparus* var. *rhyparus* Stal., head, pronotum and scutellum.
Fig. 16. *Orgamara acuta* Ball, lateral view of head.
Fig. 17. *Timodema miraculata* Ball, 1st leg.



Ball and Hartzell.

STUDIES OF THE LIFE HISTORY OF NOMOPHILA NOCTUELLA.

W. P. Flint.

This insect, one of the common and widely distributed species of the world, is of considerable economic importance, but for some reason seems to have received but little attention from American entomologists.

In 1919 the insect became so abundant as to seriously damage several newly seeded fields of sweet clover on the Experiment Station farm at the University of Illinois. Nearly every year injury by this insect is reported from some localities in Illinois.

In 1872 A. S. Packard (Ann. Lyc. Nat. Hist., N. Y., X, pp. 258-260) gave a brief account of the insect. E. P. Felt (Can. Ent., V. 25, No. 5, pp. 129-135; 1893) gives a full description of the different stages of the insect, together with observations on its feeding habits and the number of generations occurring in New York. Judging from collections made in trap cages, he estimated that three generations of the insects occurred annually in the vicinity of Ithaca, N. Y.

So far as the writer is able to learn, no detailed observations of this insect have been carried through, even for one season. For this reason an attempt was made to ascertain the facts regarding its life history in central Illinois.

Nearly full grown larvæ were taken from the field June 6, 1919, and confined in breeding cages in an outdoor screened insectary, where conditions were practically the same as in the field. The larvæ were placed in large tower cages with plants of red and sweet clover.

The insect was carried through three generations during the remainder of 1919, adults appearing first on June 19, again July 28, and September 11. Larvæ hatching from eggs laid by the adults appearing on the latest date were from one-fourth to nearly full grown on October 30, when freezing weather prevented any more feeding for the season. Adults were noted in the field the following spring on March 21, during a period of unusually high temperatures. This period of warm

weather, however, was followed by almost a month of abnormally low temperatures, with several snow storms and many nights when the temperature was several degrees below freezing. In cages, the first adults were taken on April 21, and again on June 19, August 3 and October 4. Larvæ from the last named adults went into hibernation the latter part of October, many of them being full grown at this time.

Judging by the observations made during the seasons of 1919 and 1920, four generations of the insect occur each year, being divided as follows:

Hibernating larvæ.
First brood pupæ.
First brood adults.

First generation consisting of—
- First brood eggs.
- First brood larvæ.
- Second brood pupæ.
- Second brood adults.

Second generation consisting of—
- Second brood eggs.
- Second brood larvæ.
- Third brood pupæ.
- Third brood adults.

Third generation consisting of—
- Third brood eggs.
- Third brood larvæ.
- Fourth brood pupæ.
- Fourth brood adults.

Fourth generation consisting of—
- Fourth brood eggs.
- Fourth brood larvæ.

The average period from adult to adult for each generation was fifty days. Females were observed to lay over 100 eggs. The average egg period was six days; average larval period thirty days; average pupal period ten days.

So far as our observations go, they pass the winter in the larval stage in heavy silken cases just at, or below, the surface of the ground, and protected by the overhanging leaves of plants, bits of which are incorporated in the cases.

Larvæ, as noted by Dr. Felt, feed mainly on legumes. The observations here recorded show that they seem to prefer red clover (*Trifolium pratense*), sweet clover (*Meliotus alba*), and alfalfa (*Medicago sativa*). They have, however, been found in a few cases feeding on blue grass (*Poa pratensis*), purslane (*Portulaca oleracea*), corn (*Zea mays*), wild mustard (*Brassica arvensis*), cinquefoil (*Potentilla canadensis*), white

clover (*Trifolium repens*), foxtail (*Setaria glauca*), and in one instance, soybeans (*Glycine histida*). In this case the beans had been planted on clover sod, plowed up rather late in the spring, and many of the insect inhabitants of the field previously feeding on the clover had turned their attention to the soybeans.

They feed in much the same manner as Crambid larvæ, making a shallow burrow in the ground, loosely lined with silk, and a silken tube extending a short distance from this burrow. The first instar larvæ feed mainly on the under sides of the leaves, especially where such leaves come in contact with the ground. They work as skeletonizers, leaving the coarser parts of the leaves. After the third instar, the larvæ work on both the upper and under sides, and usually consume the entire leaf, unless the veins are large and very woody. Frequently the stalk of small plants, and the stems of the leaves, are cut off close to the ground, and the leaf or plant dragged to the burrow of the insect, being pulled partly within the burrow, and then nearly all consumed. The larvæ also frequently web the leaves lightly together when feeding upon them.

The insect has been observed and reported as injuring red clover, sweet clover, and alfalfa in numerous instances during the past three seasons. In several cases, crops have been seriously damaged.

A small percentage of the larvæ have been found to be parasitized.

Complete control was obtained in fields of young sweet clover by thoroughly spraying the plants with a solution of arsenate of lead, used at the rate of two pounds to fifty gallons of water.

NEW MOSQUITO RECORDS AND NOTES ON THE HABITS OF CERTAIN SPECIES FROM CENTRAL NEW YORK.

ROBERT MATHESON AND R. C. SHANNON.

Culicella (Culex) **dyari** Coq.

According to Howard, Dyar and Knab (1915) this is a rare species, only single specimens being taken. Barber in 1910 collected at Wilmington, Mass., at arc lights, 107 males and 2 females (Dyar, Ins. Ins. Mens. 7:30, 1919). There is recorded but a single known specimen from New York. Dyar collected a single larva from Tupper Lake from which the adult issued on August 16, 1905.

During the past summer the writers found what appears to be a natural habitat of this species. Within the last two years there has been set aside a wild preserve of about eighty-three (83) acres, consisting of sphagnum bogs, marl ponds, wooded swamps and hills. There is a single deep pool known as Mud Pond and several small streams, while at one side flows a rather large creek. This is located near McLean, distant about eleven miles from Ithaca. This area lies above 1100 ft. contour line and the highest point within the area is 100 ft. Early last spring there was erected near Mud Pond a small open shelter for the purpose of protection during storms and to enable students to remain over night. On the first trip to this area (June 25, 1921) the writers found a large number (35) of what appeared to be a very striking, large, brown species of mosquito. These were all collected on the sides, underneath and within the shelter, both males and females being taken in about equal numbers. After a little study we decided the species belonged neither in *Culex* nor *Aedes*, but probably was a *Culiseta*. However no such species could be found described in *Culiseta*, so that our interest was aroused.

During the summer this species was under constant observation. Large numbers of the adults were seen in this shelter throughout June and July, the last large collection being made on July 18, (31 specimens). On September 4, no specimens

could be found. Although search was made throughout the summer in this area, not a single individual was obtained in any other location. Even sweeping failed to bring any to light although other species were obtained in abundance.

As only perfect specimens were obtained we thought the larvæ ought to be easily located in some of the nearby pools, bogs or streams. All these places were searched in vain, though numerous larvæ of other species were found. Dyar believes this species lays its eggs singly during the summer and they hatch the following spring with the melting of the snows. He states the larvæ mature early and there is but a single annual generation. All his records for collection are for May, except one taken at Tupper Lake, N. Y., on August 16, 1905, and Barber's collection in Massachusetts, in July, 1910. The interesting fact that only perfect specimens were found in our collecting would indicate either late maturing larvæ or a possible second generation. Gravid females were not found in the collection made on June 25, the first being obtained on July 9, and again on the 11th and 18th.

The adults are sluggish, resting quietly and easily captured by placing a small killing tube over them. The most interesting observation is their non-biting habit, at least as far as man is concerned. Several days and nights were spent in the shelter during both sunny and cloudy weather, but never once did this species offer to bite, though it was the predominant form there. Contrary to Barber's experience, they were not attracted to light, only two specimens being collected at the gasoline lantern used during the summer. About 150 specimens were collected, but this does not in any way represent the numbers present in and about the shelter.

Our doubt as to the identity of the species was kindly settled by Dr. H. G. Dyar, who exclaimed on being shown the specimens, "That is my namesake, *Culex dyari*!". He has now placed it in the genus *Culicella*, a genus intermediate between *Culex* and *Aedes*.

At the last moment, while examining larvæ collected on April 28, 1921, at Freeville, N. Y., for student use, we found a single specimen of *C. dyari*. This location is about two miles from what is described above as a natural habitat of this species. Furthermore, a single reared specimen of which we have the

last larval skin, pupal skin and adult, was also found in student material collected in swampy, grassy pools at Ringwood, N. Y., on May 10, 1921. This location is about six miles from the McLean habitat.

Aedes canadensis Theob.

This is one of the most common species of mosquitoes about Ithaca. It is generally believed that there is but a single generation each season, the overwintering eggs hatching at irregular intervals during the summer. Their normal habitat is woodland pools of a temporary character. The following observations would tend to show that there are more than one annual generation.

In our attempts to secure the larvæ of what proved to be *Culicella dyari*, we made two artificial pools on July 1st, in the sphagnum bogs at McLean. These pools were about 18 inches square and the water was from 10 to 15 feet deep. These bogs were dry on the surface when the openings were made. About 10 days later we found in these pools young larvæ which were remarkable on account of their blackish color. On July 18, nearly mature larvæ were found. These proved to be *A. canadensis*, not the unknown mosquito (*Culicella dyari*) as we had hoped. This would appear a new habitat for this species. The dark color of the larvæ was no doubt due to the decaying sphagnum which was eaten for food. The appearance of the species in these freshly made pools would seem to indicate that eggs were undoubtedly laid during mid-summer and hatched the same season.

The genus **Aedes.** Group **stimulans.**

Dyar (1920) has divided the genus *Aedes* into a number of groups, one of which is the *stimulans* group. During the past spring we made observations on three closely related species of *Aedes*—*A. stimulans* Walker, *A. excrucians* Walker (*abfitchii* F. & Y.) and *A. fitchii* F. and Y., all belonging to the *stimulans* group. Furthermore, Dyar considers each one of these to represent typically the three series into which he divides the *stimulans* group and around each are placed the known North American species according to their relationships.

While collecting larvæ on April 19, in the Renwick flats, at the head of Cayuga Lake, a single larva of *A. stimulans*

and two of *A. excrucians* were taken in a deep pool on open ground. The pool had a mud bottom covered with leaves. On April 21, Mr. Sibley brought in from Ringwood a great number of mature larvæ and pupæ. This material consisted of two species, *stimulans* and *excrucians* (*abfitchii*). A large number of isolations were made, but they proved difficult to rear under artificial conditions. However, seventeen adults were secured, the last larval and pupal skin being saved. These were all mounted and 5 proved to be *excrucians* and 12 *stimulans*. Of these we had 4 males of *excrucians* and 6 males of *stimulans*. Not a single *fitchii* larva was found in this collection. Mr. Sibley reported that these larvæ and pupæ were present in immense numbers.

On May 10, the writers visited Ringwood and located the pool described by Mr. Sibley. It was the last of three pools situated in the woods in a line back from the roadway at an elevation of about 1300 feet. The first pool was covered over by a dense mat of duckweed and in this no mosquito larvæ were found. The second pool which is of considerable size and depth, is evidently a pothole and is isolated from the other two. Practically no aquatic vegetation was present and the bottom and margins had a dense covering of decaying leaves and mud. Immense numbers of pupæ and relatively few larvæ were present along the edge and about floating tree trunks in the pool. None were found in the open water where it was deeper than three feet. The presence of such vast numbers was all the more surprising, as Mr. Sibley found none in it on April 21st. A greater surprise awaited us when we learned that this vast number of larvæ and pupæ in pool number two consisted of but a single species—a pure culture of *A. fitchii*.

Pool number three, which is similar but smaller than number two, did not contain at this time a single larva. It was in this pool that Mr. Sibley, eighteen days earlier, found such immense numbers of *A. stimulans* and *A. excrucians*.

These observations are of interest in showing an instance of two species, *A. stimulans* and *A. excrucians*, inhabiting but a single pool, even though a second pool of similar character is only a short distance away. Then a third very closely allied species, *A. fitchii*, occupies the second pool, to the exclusion of the one occupied by the first two species. Another point

of interest is the complete emergence of *A. stimulans* and *excrucians* at least two to three weeks earlier than *A. fitchii*, i. e., the pupal period of the former species was at its height about April 21, while the latter was on May 10.

These three species proved vicious biters and were the most troublesome, where they occurred, during the early spring months and lasting well into July.

Mansonia perturbans Walker.

Mansonia perturbans is a mosquito of wide distribution. However there are only two published records from New York State—Rochester and Ithaca. The recorded material Ithaca was collected by Comstock in 1891. The writers have found only a single specimen in the Cornell collection bearing an Ithaca label, but no date. During the past summer this species has not been taken around Ithaca. On a trip made to North Fairhaven on July 3–5, this species was met with in large numbers. North Fairhaven lies on the shores of Lake Ontario and is surrounded by large swampy areas, providing ideal conditions for the development of this species.

This species maintained its reputation of being a vicious biter. It would bite freely in the woodlands during the day. In the evening they became extremely annoying in and around the house. Their attacks continued after dark, even after all lights were extinguished. One of the writers was compelled to change his sleeping place after 10:30 P. M. to a more protected room. This activity of the mosquito would indicate that this species is not entirely crepuscular in feeding habits as stated by Howard, Dyar and Knab. They also have a mean habit of attacking low down, crawling up inside one's trouser legs. It might be added that these experiences occurred at an isolated farm house about two miles from the village.

Swarming of the males was observed just at dusk, the individuals being barely discernible. The swarm was seen at the edge of a cattail pond, the height being from three to five feet. The swarm contained about thirty individuals, of which eight were captured.

Anopheles quadrimaculatus Say.

This species has always been supposed to be a common one about Ithaca, breeding in large numbers in the marshy areas

at the head of Cayuga Lake. Early in the season we attempted to secure specimens for class use, but all collections made and adults reared proved to be *A. punctipennis* Say. This induced the writers to make a rather intensive survey of a considerable area bordering the city park located at the head of the Lake. A student spent a good part of his time locating pools, making collections and rearing adults. The writers also made extensive collections of larvæ and adult mosquitoes found in this area. What was our surprise to find that in all this material there was not a single individual of this species. The only specimens obtained during the season were collected in two private houses located on the heights about a mile distant from these marshes. In one house two females were obtained on August 15, and in November we collected two more in another private house.

Ithaca used to be considered a malarial city and numerous cases of this disease occurred every summer. In talking with the health officer, Dr. Crum, he informed us that not a single case was reported this past season and scarcely any for a number of years previously. One case came to our knowledge last summer and that person arrived in the city suffering from the disease. This is an interesting coincidence between the apparent disappearance of the chief malarial carrier of this region and the disease.

Anopheles punctipennis Say.

This is undoubtedly the dominant anopheline in the Ithaca region. It has been taken in large numbers wherever the writers collected. It proved one of the troublesome biters all season and the larvæ were collected in all sorts of locations. In the marshes the larvæ occurred in large numbers in a great variety of pools. Roadside puddles of a very temporary character often contained a much larger percentage of this species than any other. In puddles formed by local showers in wagon ruts this species was generally present, showing the great abundance of the species. Many rearings were made and in all cases only adults of this species were secured.

On the hills surrounding Ithaca it was very abundant and we were always sure to find them when collecting. If the human reservoir of malaria continued in Ithaca after the gradual disappearance of *A. quadrimaculatus* it is certain that *A. punctipennis* must be a poor host for the development of the malarial organisms in this region.

Anopheles walkeri Theobald.

This anopheline is widely distributed in Eastern North America, but is rarely taken or seen in collections. There are no records of it having ever been taken in New York State. On July 3, 1921, five specimens, while in the act of feeding, were collected at North Fair Haven. A single specimen was taken on August 5, at Duck Lake, while in the act of biting.

Wyeomyia smithii Coq.

Wyeomyia smithii Coq. is well known to be an obligate inhabitant of the pitcher plant (*Sarracenia purpurea*) and practically all that is necessary to get the mosquito is to find the plant.

Pitcher plants are well known to occur in New York State, but to date there have been no records published of the occurrence of the mosquito in our boundaries.

The sphagnum bogs of McLean, N. Y., contain numbers of pitcher plants and during June and July, when these plants were examined, many of the larvæ of this unique mosquito were found in them. Only plants containing an abundance of fluid, as yet uncontaminated by decaying insects, were inhabited.

The swamp lying close to Duck Lake, N. Y., is an excellent region for pitcher plants, where they flourish in great abundance. The larvæ of *Wyeomyia smithii* occur in great numbers, and during the middle of August, when this region was visited, large numbers of the larvæ could be obtained from the plants. The adults were also observed, flying amongst the low vegetation.

Successful rearings were easily obtained by isolating the larvæ in vials and using the fluid from the plants as the rearing medium.

ECDYSIS IN TMETOCERA OCELLANA SCHIFF.

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An examination of the literature on the Bud-moth, (*Tmetocera ocellana* Schiff.) reveals little concerning the moulting of such a common pest. In fact there has been very little investigation of the moulting of any of the Lepidoptera and especially of the measurement of the moulted head capsules. In response to the need of detailed study on this phase of the life history, the writer has assembled the following notes.

A brief summary of the development of the subject may be of value. Several writers have previously called attention to the moulting habit of the Bud-moth, but there still remains an opportunity for considerable investigation along this line. Mr. H. G. Dyar, of the United States National Museum, several years ago made a valuable contribution in the form of a series of head measurements of the first five instars of the Bud-moth larvæ. His notes were published by Prof. M. V. Slingerland (1893).* Further information has been supplied by Prof. Slingerland in the same bulletin. Mr. G. E. Sanders and A. F. Dustan (1919)† in their work on the Bud-moths of Canada, have added likewise to our knowledge of the ecdysis of *T. ocellana* Schiff. The numerous other papers, chiefly of economic importance, add very little to the study.

METHOD OF STUDY.

This study has been divided into four parts. (1) The moulting process, (2) The number of moults, (3) The measurement of the moulted head capsules, (4) The shape and structure of the head capsules.

The larvæ used in obtaining these records were hatched from eggs laid in confinement and were examined and fed at least once a day. Each larva was placed in a separate four dram vial with a small portion of the leaf as food. As soon as the moults occurred, the head capsules were removed and placed in individual jelletin capsules and properly labelled by means of colored papers according to the number of the moult. All measurements were made at the end of the season.

THE MOULTING PROCESS.

The process of moulting, as in all insects, is a delicate one. The larva at this time is weak and helpless and very susceptible to injury. Nature, however, has provided ample means of protection during this period. The larva never moults in the open, but always conceals itself in some manner. Sometimes it may be a curled leaf with a few silken threads, but more often it forms a well constructed silken moulting case. This case may be entirely closed or partly open at one or both ends. The larva often moults within its feeding case, which serves as a means of protection during the entire life of the larva, but at this time provides special protection. As a rule, moulting occurs in a closed moulting case.

The feeding case is composed of a mass of silken threads tightly woven together into a trumpet shaped tube somewhat resembling the feeding tube of the Apple leaf crumpler (*Mineola indigenella* Zell.) but is smaller and neater. The frass is utilized by the larva and woven into this silken tube, giving it a blackish color and forming a hard protective covering. Immediately following a moult, within the feeding case, the moulted skin and head capsule will be found inside the feeding tube. These are pushed by the larva to the end of the case where they become entangled with the silken threads of the case and are later imbeded in the silk and the frass of the case.

It is possible to determine when a moult is approaching. Several hours or even a day before hand the approaching moult is indicated by a whitish membraneous area between the head and the prothoracic shield and a decided constriction at this point. The moult follows shortly afterwards.

When ready to moult the skin loosens at the thorax and the old integument, including the prothoracic shield, moves off the posterior end of the larva. The larva frees itself by crawling out of the skin. The head capsule comes off separately and in several cases under observation popped off about the same time the larva freed itself from its skin. Only a short time elapses from the first indication of a moult until the skin is shed. In one instance a larva was in the process of the fourth moult at 4:52 P. M., the old head capsule had worked half

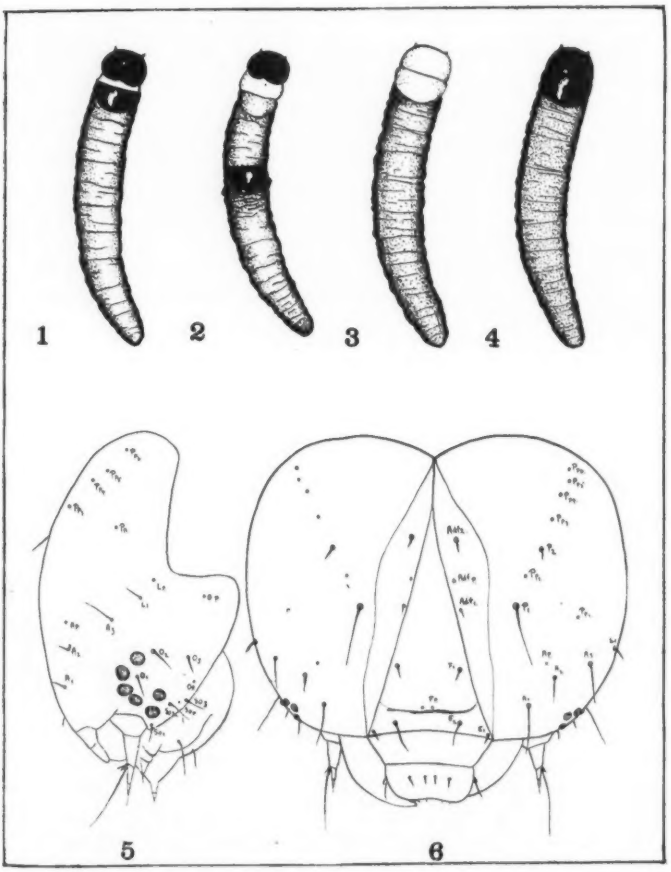

FIG. I.

1, Larva showing first indication of approaching moult. 2, Larva in process of moult. 3, Larva immediately after moult. 4, Larva showing head and thorax fully colored. 5, Lateral aspect of head capsule. 6, Cephalic aspect of head capsule.

Adf_1, Adf_2—Adfrontal setæ.
Adfp—Adfrontal puncture.
F—Frontal seta.
Fp—Frontal puncture.
E_1, E_2—Epistomal setæ.
A_1, A_2, A_3—Anterior setæ.
Ap—Anterior punctures.
L_1—Lateral setæ.
Lp—Lateral puncture.
P_1, P_2, P_3—Posterior setæ.
Pp_1, Pp_2—Posterior punctures.
O_1, O_2, O_3—Ocellar setæ.
Op—Ocellar punctures.
So_1, So_2—Sub ocellar setæ.
Gp—Genæ puncture.
SOp—Sub ocellar puncture.

way off the head and the skin had worked part way off the body so that the prothoracic shield rested over the second abdominal segment. At 4:55 P. M. of the same day the head capsule was cast and at 4:59 P. M. the larva succeeded in freeing itself from its skin.

NUMBER OF MOULTS.

The number of moults apparently varies in different parts of the country. Mr. G. E. Sanders (1919)* found in Canada that there are only seven moults. The majority of the larvæ entered their winter quarters in the third instar, while a few moulted a third time and entered hibernation as fourth instar larvæ. In Pennsylvania the writer has obtained ten larval moults. The majority of the larvæ enter hibernation in the ninth instar, the other two moults occurring the following spring. A small percentage hibernate in the eighth instar. Considerable variation may be expected where the number of instars are as high as in the Bud-moth.

MEASUREMENT OF HEAD CAPSULES.

In moulting, the head capsule and thoracic shield, because of their chitinous nature, retain their original shape and thus lend valuable characters for a study of this kind. Advantage was taken of this fact and the head capsules of a number of each instar were preserved and measured.

TABLE OF MEASUREMENTS OF HEAD CAPSULES OF *T. ocellana* Schiff.

Instar	Number of head capsules measured	Average Length	Average Width	Dyar's* Measurements
1st	30	.142 mm.	.216 mm.	.225 mm.
2nd	34	.188 mm.	.275 mm.	.288 mm.
3rd	21	.258 mm.	.363 mm.	.363 mm.
4th	16	.299 mm.	.436 mm.	.43 mm.
5th	27	.356 mm.	.513 mm.	.56 mm.
6th	28	.404 mm.	.572 mm.	.....
7th	22	.457 mm.	.645 mm.	.....
8th	15	.510 mm.	.733 mm.	.....
9th	23	.517 mm.	.760 mm.	.....
10th	16	.629 mm.	.975 mm.	1.05 mm.

* Cornell Bull. 50, 1893.

SHAPE OF THE HEAD CAPSULES.

There are certain differences in the shape of the head capsules that help to distinguish some of the instars. The head capsule of the first instar is distinctly flattened while the capsules of the remaining instars are rounded and easily separated. A comparison of the heads further show that those of the first seven instars are proportionally longer than broad, while the eighth, ninth and tenth larval heads are proportionally broader than long. These differences in shape, as well as the differences in size, aid in determining the different instars.

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HATCHING IN THREE SPECIES OF NEUROPTERA.*

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This paper deals with the process of hatching in three species of Neuroptera, viz., *Chauliodes pectinicornis* Linn, *Micromus posticus* Walker, and *Chrysopa oculata* Say. The observations were made with special reference to the egg bursters. This account is therefore a brief description of the appearance of the eggs at hatching, the process of hatching and a description of the special structure enabling the embryo to leave the shell. This structure in the three species mentioned is of the same general type, but there are important differences. The general process of hatching in each case, as well as the appearance of the eggs at hatching, are very similar.

1. **Chauliodes pectinicornis** Linn.

The function of the egg burster in this species was observed in 1912 by H. S. Barber, who did not publish upon the subject. He very kindly sent the writer his sketches and photographs and supplied the fresh material upon which these observations were made. This material consisted of a large number of eggs deposited June 16, 1919, in confinement by a gravid female caught at lights at Plummer's Island, Maryland. When received, June 20th, they showed advanced embryological development and hatched under the writer's observation June 24th.

The eggs all lay on what was the dorsum of the embryo (Fig. 4), the ventral side up, and with the prominent knobbed micropyles all pointing the same direction. When these eggs were ready to hatch, the two black eye spots could be very plainly seen each side the mid-ventral line and near the micropylar region. A little posterior to these were the very prominent bifid amber-colored mandibles. Furthermore, in the mid-ventral line between the eyes and above the mandibles was seen a thin chitinous carina resembling a small knife blade. This

* Contribution No. 78 from the Entomological Laboratory, Kansas State Agricultural College.

was found to be the egg burster. It could be seen that it was bilobed, but the upper lobe showed the more distinctly. In this case the eggs hatched when these characters showed most plainly. The warmth of an electric light bulb after a cool night started the whole mass hatching.

The first evidence of the beginning of hatching observed with a binocular was a very slight raising and lowering of the mandibles, effected, it is believed, by the embryo working itself upward then receding slightly. The upward movement was somewhat quicker than the downward one. The head was gradually advanced, thereby bringing the burster next to the chorion. This movement continued from one to four minutes

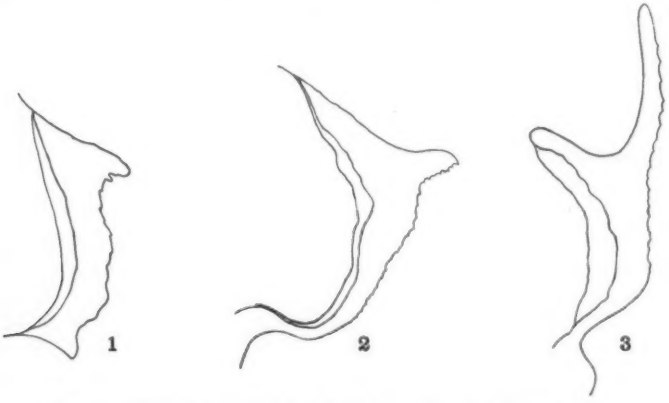

Fig. 1. The egg burster of *Chauliodes pectinicornis* Linn. × 215.
Fig. 2. The egg burster of *Chrysopa oculata* Say. × 300.
Fig. 3. The egg burster of *Micromus posticus* Walker. × 300.

in different eggs observed. Finally the upper lobe punctured the chorion and a slit was cut for the entire length of the burster. The embryo forced the soft clypeal region through the opening, which caused the rent to broaden, then tear, almost entirely at the upper end. The clypeus was translucent to grayish in color, so contrasted sharply with the chorion. The embryo forced its head through the rent, followed by the thorax, but the chief advance was made by the dorsum. When the embryo had emerged to about half its length, it stopped and prepared to cast the embryonic molt.

One could very clearly discern a little stream of silvery bubbles of air entering the pharynx and collecting in the intestine, thereby causing an observable inflation. As a result of this inflation in the thoracic region, together with the shifting forward of the embryo, the thin membrane parted over the prothorax in the mid-dorsal line. This rent rapidly lengthened to the metathorax. The larva then pushed its thorax through the rent, bending its head ventrad. The thin membrane slipped off the mouthparts very slowly. In a minute or so the head was pulled free and the larva rested supported by the end of the abdomen until the chitin hardened. After about thirty minutes the larva pulled its abdomen from the molt and walked away. This molt lay in a crumpled heap in the lower end of the rent. The entire process of hatching from the first visible movements to walking away required about forty-five minutes.

The egg burster (Fig. 1) is a thickening and specialization of the embryonic cuticula* over the anterior part of the head in the median line. The burster proper is an inverted V-shaped ridge, with upper and lower lobes between which the carina bends outward and is beset with about ten minute teeth or irregularities. At the sides, the heavy chitinized parts are continuous with the molt, but the line of demarcation can generally be distinguished.

2. **Micromus posticus** Walker.

Hatching in the Hemerobiidæ has been observed by the writer in four species, viz., *Hemerobius humuli*, *H. stigmaterus*, *Sympherobius amiculus* and *Micromus posticus*. It occurred in the same way in all these species, the few differences recorded are probably individual. As a type for the family, hatching in *Micromus posticus* will be described. This species is one of the most abundant in the eastern part of the United States, and one of the larger ones in size.

The chorion was observed to be entirely smooth, unsculptured, shining and irridescent. As embryological development proceeded, the outlines of the embryo could be readily seen, since the chorion was very transparent. When the eggs were ready to hatch, the three pairs of thoracic gray color patches

* Smith, Roger C. The Process of Hatching in Corydalis cornuta Linn. Annals Ent. Soc. Amer., Vol. XIII, pp. 70-74, 1920.

could be distinctly seen. The posterior three-fourths of the egg was pinkish, even reddish. In the mid-ventral line, just below a line connecting the eyes, could be seen the egg burster. The eggs lie on the dorsum with the venter uppermost. Just before hatching the egg burster and the general coloration of the embryo appeared quite distinct.

The first visible evidence of the beginning of hatching was certain peristaltic movements of the abdomen. The embryo appeared to push itself upward by means of the abdomen. The end of the abdomen was first pulled by these so-called peristaltic movements towards the posterior pole of the egg and as a result of crowding there, pressure was exerted at the anterior pole. This upward pushing, it has been observed, may continue at intervals for ten to thirty minutes. As a result of this pushing, the egg burster was closely applied to the chorion. As the pressure continued, the upper end of the toothed burster was pushed through the chorion. It is difficult to ascertain sometimes the exact time the burster pierces the chorion, for, under pressure the burster often appears through when it is not yet through, due to the transparency of the chorion. After the upper end of the burster was through the chorion, the upward and outward thrusts of the embryo became more pronounced. At each upward thrust, more of the chorion was cut, the cutting proceeding away from the micropyle. By this time the clypeal region of the head of the embryo could be seen in the rent. It was dull and whitish in contrast to the shining glassy chorion. The burster cut to its full length, and in the meanwhile the embryo pushed its head through the upper part of the rent. This is followed by the thorax and a part of the abdomen. At the time that the thorax was well out, the thin embryonic cuticula split over the prothorax, due in part to its being attached to the chorion in the mid-ventral line. The exact time could be ascertained by observing the straightening up of the dorsal setæ. The thorax and a part of the abdomen were pushed through the molt, but the mouthparts and head appendages were retarded so the larva formed an inverted U over the egg. The mouthparts were pulled from this thin membranous cuticula slowly and carefully. The molt with the attached egg burster slipped down between the labial palpi and the antennæ. The burster and the thin shrivelled molt

lodged finally in the lower end of the rent of the chorion. The larva rested until its legs would bear its weight, and then pulled its abdomen from the egg shell and molt. The burster, which is a part of the molt, could be seen with the unaided eye. The entire process from the first piercing of the chorion to walking away requires from 15 to 20 minutes.

The egg burster is again a specialization of the embryonic molt, but differing considerably from those of other families seen. It is a toothed keel, but the upper half is free and extends over the clypeal region of the head. There are no prominent lobes, but the apex of the ridge bears from 15 to 20 small saw-like teeth. There is a rather marked diamond-shaped cap which fits over the buccal region. This cap is thought to be the line of demarcation between the heavier and lighter chitinization of the molt. This burster apparently resembles that of Osmylus as figured by Hagen (1852).

3. **Chrysopa oculata** Say.

Hatching in this species, and in all closely related species of Chrysopidæ so far seen, takes place in a manner almost identical with that described for *M. posticus*. The chief accounts seen in literature concerning hatching in this family are the writings of Hagen (1859, 80) in which reference is made to a cephalic saw by means of which the first opening is effected. Hatching has been incorrectly described by several writers as effected by the mandibles of the embryo piercing the chorion, or the upper end of the egg being cut off. The position of the embryo in the egg would render the first explanation, a priori, impossible and in the case of the second there is no cap on the egg to be lifted.

Eggs ready to hatch show rather clearly the outline and parts of the embryo, as the chorion is transparent to a considerable degree. The two very prominent eyes or ocellar fields stand out clearly and can be seen with the unaided eye. On the ventral side in the mid-dorsal line between the eyes can be seen a short, dark line. This line is the cephalic saw of Hagen, or the egg burster. Just before hatching, it appears quite dark or black, perhaps due to an increase in chitinization. Hatching can be readily observed without a long wait by taking some eggs from a cluster for observation in which most have already hatched.

A brief account of a typical instance of hatching follows: The embryo began a series of movements calculated to pull the tip of the abdomen towards the posterior pole of the egg. This region became crowded and the embryo pushed upwards and outwards slowly. The upward movement was rather quick and with some effort, while the downward one appeared to be a slipping back to its previous position. Along with these movements, there was some outward pressure brought to bear

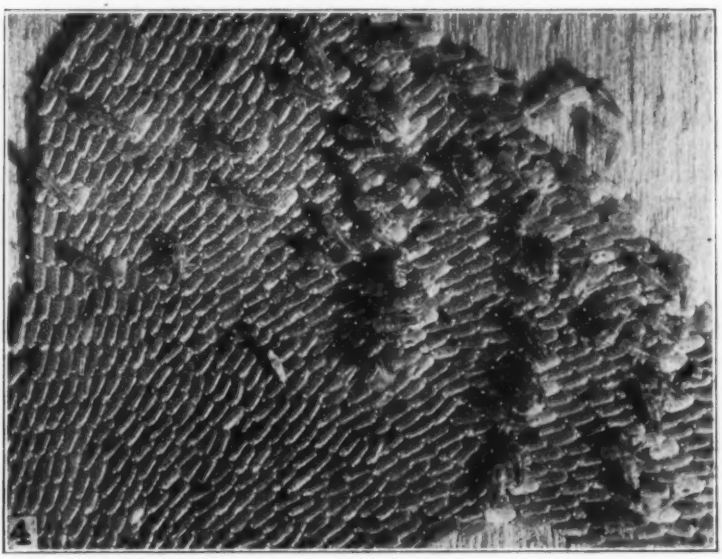

Fig. 4. An egg mass of *Chauliodes pectinicornis* hatching. (Photo by H. S. Barber, 1912).

on the head region which culminated in the penetration of the chorion by the upper lobe of the burster. It was later observed that it is frequently difficult to ascertain if it has cut through the chorion or whether it is merely closely appressed. In this case, two whitish triangular areas appeared on each side of the burster, their bases next to it. The writer interpreted these as air bubbles beneath the chorion, the edges of which had been raised up in the cutting process. As the embryo continued the upward pressure, the burster was pushed through

for its entire length, cutting the chorion before it. The rent was then torn at both ends, chiefly the upper, by the outward pressure of the head of the embryo. The dorsum of the head is pushed through the opening, perhaps aided some by blood pressure, and as a consequence, the slit in the chorion tore anteriorly to the micropyle. The abdomen was the pushing agency. It moved upward by a series of contractions and expansions, pushing the thorax before it. The mouthparts and legs appeared to be held by the embryonic molt so that they lagged behind in emergence. The chorion slipped back over the eyes as the thorax was pushed up and the burster with the molt remained at the lower part of the incision with the cast skin. The embryonic molt was attached to the inside of the chorion in the mid-ventral line just below the rent. Sufficient strain was exerted on this molt by the emergence of the embryo to cause it to tear over the thorax in the mid-dorsal line. The upward pushing continued and the thorax became arched over the egg. As the thorax and abdomen appeared, the setæ thus freed sprang into their normal position. When the abdomen was well out of the egg, the larva began to straighten up. This withdrew the mouthparts and the legs from the molt. They were drawn out slowly and finally the claws were freed after some difficulty.

As soon as the mouthparts and legs were freed, the larva raised itself erect and even bent backwards. By these movements it separated the appendages from each other, for they appeared to adhere slightly. During this performance and until the chitin was hard, the larva supported itself wholly by the end of the abdomen. Finally, after some ten minutes, the larva brought itself forward and rested on its legs. It then rested for a few minutes longer, after which it sought the stalk of the egg by which it descended to the substratum.

Later observations show that it is not always the upper lobe which first pierces the chorion. Sometimes it appears that the whole burster is slowly pushed through the chorion at about the same time. Larvæ rest for a varying length of time on the egg shell. Generally is it about fifteen or twenty minutes, but this period may be much prolonged. One often sees a batch of eggs with a larva resting on each. The empty shells are pure white, and all have a prominent

rent at the upper end to one side of the micropyle. The embryonic molt generally protrudes slightly from the lower end of the rent.

The burster is a saw-toothed carina, .118 mm. long, and .029 mm. wide at the lobe. In cross section the burster is V-shaped, due to the broadening at the base. There are 20 to 30 minute teeth along the cutting edge of the burster. The lobe generally has a sharp tooth at its tip, but not always. The bursters of other species of Chrysopa as far as seen are practically identical with that of this species, and hatching shows no essential variations.

The writer has observed hatching a great many times in each of these families, but especially among the Chrysopidæ and Hemerobiidæ. At no time has the egg bursters been observed to fail in their critical period of usefulness. Embryos sometimes die before hatching, but no case has yet been seen where it was thought that death had occurred because the egg burster had failed to cut the chorion. They are highly efficient structures.

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AN EXTREME CASE OF DELAYED FALL EMERGENCE OF HESSIAN FLY.*

(**Phytophaga destructor** Say).

By WALTER H. LARRIMER, Scientific Assistant,
U. S. Bureau of Entomology, West Lafayette, Indiana.

During June, July, and August, 1920, over the northern portion of the east central states, with the exception of a small isolated area in north central Illinois, the mean temperature was from three to six degrees below normal and during September and October for this area the mean temperature was from six to ten degrees above normal. Rainfall was more or less general in occurrence over this area, but the amount varied remarkably in different sections as well as in immediate localities. It is to be expected, therefore, that such irregularities in two of the most important of the controlling factors of Hessian fly emergence would correspondingly influence the emergence and activity of the fall brood of 1920.

The emergence as observed at Lafayette, Indiana, may be indicated by a graphic record of egg counts made daily from September 23 to October 25. Fifty wheat plants of the two leaf stage were marked and each morning the eggs were counted and removed. When the plants grew to a size that was no longer as attractive to the female flies for oviposition as the smaller plants, the markers were transferred to a fresh lot of the desired size from a later planting, care being taken to make sure that these new plants were clear of eggs. In Fig. 1 the graph shows the daily egg record for the period indicated.

Very few wheat plants were available for oviposition at the time of the first peak of emergence and the resulting oviposition was of course concentrated on these few plants, while an almost unlimited supply of wheat was available at the time of the second peak on October 17. Therefore the true relation as to the magnitude of the two waves of emergence is not truly represented by the graph. However, the purpose is not so much to show the proper relative proportion of the waves as to mark the time of each.

* Published by permission of the Secretary of Agriculture.

From a similar set of records made at Centralia, Illinois, by Mr. W. B. Cartwright, of the U. S. Bureau of Entomology, the crest of emergence of the "late wave" at that place was determined to be on October 12, or five days earlier than at Lafayette. From these two records of continuous observations, verified more or less by a number of fragmentary data, it was determined that the emergence of the "late wave" occurred in the reverse order to the normal, that is, it occurred

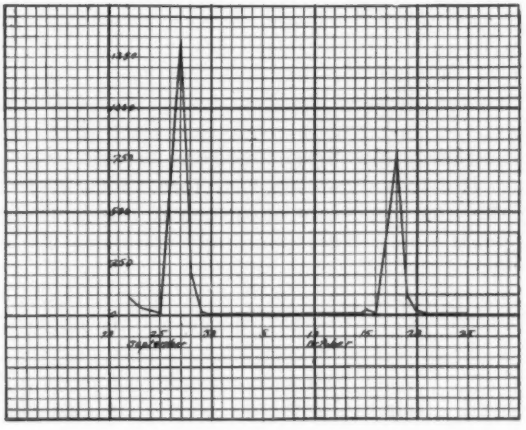

Fig. 1. Graph showing Hessian fly egg counts made at Lafayette, Indiana, September and October, 1920.

earlier instead of later to the southward. The following map (Fig. 2) indicates approximately the dates of emergence of the "late wave" wherever it occurred in the section indicated. From the latitude of Cincinnati southward these dates come within the recommended safe sowing dates and for that area the emergence can be considered normal.

A study of pupation records for the beginning of the period will also be quite interesting. These records were made by frequent examination and dissection of flaxseeds in lots of one hundred each, only those containing either larvæ or pupæ of Hessian fly being included. In the graph of pupation (Fig. 3) the number of pupæ is indicated by the figures on the left and the number of larvæ by the figures on the right.

It may be noticed that the crest of the pupation curve on October 11, did not reach one hundred, indicating that approximately forty per cent of the larvæ did not pupate during the time covered by the graph and subsequent examinations proved that they passed the winter in the old summer stubble.

During the spring of 1921, from pupation records made as previously explained, it was determined that pupation of these "hang-over" larvæ began March 17 and was practically

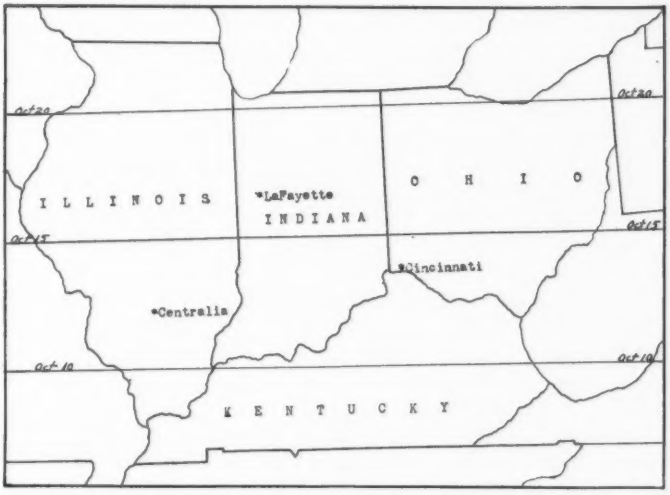

Fig. 2. Map indicating the approximate dates of emergence of the "late wave" of Hessian fly in October, 1920.

completed by April 10. Emergence of adults from these pupæ began March 29 and continued throughout the month of April. A very few healthy larvæ failed to pupate, but these were so very hard to find in the field that further observation on them was not practicable.

Pupariation is a term that it has been found convenient to apply to that activity by which the larvæ of Hessian fly change to the flaxseed stage, as distinguished from actual pupation. Pupariation records were made on the larvæ, offspring of the late wave, in order to determine the condition in which they entered and passed the winter. At frequent intervals 100

specimens of fly were examined as found and the percentage of these larvæ and puparia noted. In one field, pupariation of these larvæ began on November 22, was half completed by December 9, and completed January 4. In another field, pupariation began December 2, was half completed by January 4 and completed February 28. Pupation of these larvæ in both fields began March 18 and was practically completed by April 10. A very small number of larvæ remained to produce stragglers or to hang over until fall. Adults began emerging March 29 and continued throughout April.

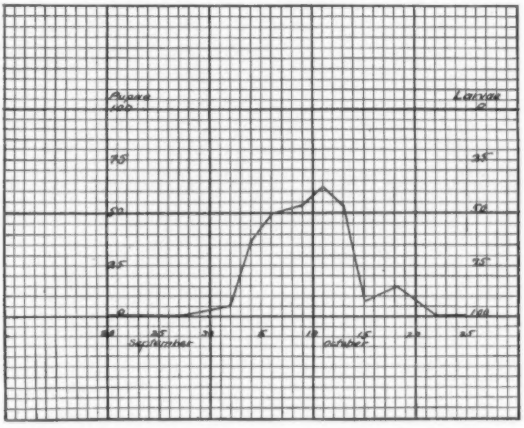

Fig. 3. Graph showing the pupation of Hessian fly of the "late wave" 1920.

By a study of puparia, offspring of the normal emergence the preceding fall, it was determined that pupation and emergence occurred on approximately the same dates as in the case of "hang-over" and "late wave." Thus the pupation of larvæ and the emergence of adults of all Hessian fly in the spring of 1921 took place at about the same time, regardless of their origin.

POLLINATION OF RED CLOVER BY TETRALONIA AND MELISSODES.

JUSTUS W. FOLSOM.

The fact that bumblebees are important as pollenizers of red clover has been established by means of numerous experiments dating from the time of Darwin. Their importance in this respect depends, however, upon their numbers at the time when the clover is in bloom. Thus, in second-year clover, in Illinois, bumblebees are highly important as pollenizers of the second crop, for they are abundant in late July, in August and September. They are unimportant as pollenizers of the first crop, however, for in June the only winged bumblebees in existence are the comparatively few queens that have survived the winter, and these spend a large part of their time in the nest, rather than in the field. The June crop is certainly not pollenized to any considerable extent by bumblebees. In fact, it seldom yields much seed as compared with the second crop in the same locality.

Twenty years ago it was taken for granted that there was not enough seed in the June crop to pay for its extraction, but since then more and more farmers have found it profitable, now and then, to cut the June clover for seed instead of hay, and have obtained from one-half a bushel to two bushels of seed (possibly more) per acre in Illinois.

How is the June crop pollenized? From correspondence and from inquiries at Farmers' Institutes I learned that in a few instances the yield of seed had occurred in a region where Italian honey bees were common and had been seen working on the flowers. Now honey bees of this race are undoubtedly important pollenizers of red clover, as Dr. A. D. Hopkins found, and as I have since ascertained. There were, however, some instances in which seed had been obtained from the June crop in places where there were no Italian honey bees; so there still remained some mystery in regard to the means of pollination of the clover field in June.

Mr. W. P. Flint has had *Tetralonia dilecta* Cress. under observation for several years, and has repeatedly found good yields of seed from fields in which this bee had been abundant.

This *prima facie* evidence, brought to my attention by Mr. Flint, led me to make the following observations and experiments with the object of proving whether certain species of *Tetralonia* and *Melissodes* pollenize red clover or not. In this study I had the assistance of Mr. F. Q. Otanes, a graduate student, who was investigating the general subject of insects in relation to the production of clover seed. The species used in our work were kindly determined by Mr. Henry L. Viereck.

1. *Tetralonia dilecta* Cress. = (*T. speciosa* Rob., not Cress.). May 19, 1921, *Tetralonia dilecta* was present, though not abundant, in fields of red clover on the University farm, Urbana, Illinois, and was working busily on the blossoms. The proboscis, thrust into the flower, was visible through the corolla, and evidently extended to the bottom of the corolla tube. Specimens collected from clover heads, taken to the laboratory and examined under a microscope, showed many pollen grains, especially on the mentum and the branched hairs of the mentum, but also on the maxillæ; in fact, pollen grains occurred almost anywhere on the ventral aspect of the mouth parts. These pollen grains were indistinguishable from those of red clover.

May 24, when the bees were abundant, a root cage with parallel glass sides and a cover of wire screen was taken to the clover field; in it was placed a solid row of clover heads in full bloom, and into the cage were introduced specimens of *Tetralonia dilecta*. Some of the bees set to work on the blossoms, and their operations were studied under a hand lens.

It was essential, of course, to determine if seed would be produced by plants upon which *Tetralonia* had worked, and from which all other insects had been excluded. To this end, red clover plants were taken which bore heads with unopened buds; opened heads having been removed from the plants. These plants were transplanted to a large flower pot covered with a cage of wire screen with a mesh of one millimeter, and placed out of doors. In a day or two some of the heads were in bloom and bees were introduced into the cage. May 26, I put thirty individuals of *T. dilecta* into the cage; a few of them were seen to work on the blossoms during the same day; after twenty-four hours, however, all the bees had died. May 31, Mr. Otanes put several more bees into the cage, and some of these also were observed to work on the flowers. The florets

were then allowed to dry, and were examined for seed July 1, by Mr. Otanes and myself. From 789 florets (not counting undeveloped florets that could not have been pollenized) we found 171 seeds. In other words, 21 per cent. of the flowers had been pollenized by *Tetralonia dilecta*.

As a check experiment, red clover plants with heads in bud, but not as yet in bloom, were planted in two flower pots, covered with wire cages and placed out of doors, just as in the preceding experiment, but no bees were put into the cages. After three weeks, when the heads were examined for seed, the first cage contained 357 florets and no seeds; the second, 287 florets and no seeds.

Tetralonia dilecta, abundant until the middle of June, became rare by June 30, but a second species of bee soon appeared on the scene and engaged our interest.

2. *Melissodes bimaculata* LeP. This black species appeared July 5, was common July 7 and 12, but was falling off in numbers July 21. *M. bimaculata*, swifter of flight and more alert than *T. dilecta*, worked actively on clover blossoms in the field. Specimens taken from clover heads showed much pollen, undoubtedly that of red clover, on the mentum, some pollen on hairs adjacent to the mentum, and considerable pollen among the hairs under the eyes.

As before, red clover plants with unopened heads were potted July 12, and covered with a wire cage. July 14, several heads being partly in bloom, I placed seven individuals of *M. bimaculata* in the cage at 2:30 P. M., and one of these was working on the heads ten minutes later. July 15, six of the bees had died. July 16, Mr. Otanes put in eleven more bees; and July 19, five more, some of which were seen to work on the flowers. In all, twenty-three bees had been introduced.

As several bees had apparently been pollenizing florets, we expected to get some seed, at least; but when the dried heads were examined by Mr. Otanes, August 4, the 216 florets that were present yielded only two seeds. Thus the results of this experiment were negative. In a second experiment, however, the results were different.

In this experiment, plants with unopened heads were potted and covered with a cage July 21. July 23, fifteen specimens of *M. bimaculata* were put into the cage; and July 25, sixteen more. Many of these bees were seen working on the flowers.

August 12, the heads were examined for seed, and the 11 heads present, with 293 florets, yielded 90 seeds, or 30 per cent.

These observations and experiments are simple but conclusive. They prove that *Tetralonia dilecta* pollenizes red clover to an important extent in the latter part of May and in June (in central Illinois), and that *Melissodes bimaculata* also is an efficient pollenizer of plants that bloom during July.

The present summary is simply for the purpose of placing these facts on record; a detailed account of further studies being left for a future article.

ARE THERE TWO SPECIES OF THE OYSTER-SHELL SCALE?*

GRACE H. GRISWOLD.

The Oyster-shell Scale (*Lepidosaphes ulmi*, L.) has been a subject of study on the part of the writer since the spring of 1919. During the summer of that year, observations were made on the biological development of this insect on lilac. In the fall, while making egg counts from various host plants, it was noticed that the scales formed on apple trees seemed to differ in appearance from those on lilac and some of the other ornamental shrubs and trees. It was therefore determined to make a comparative study of the biological development of the insect on apple and lilac the following summer.

Studies of this insect have resulted in the finding of three distinct differences between what may be called the apple and lilac forms:

1. Differences in the appearance of the scales.
2. Differences in biological development.
3. Differences in morphological characters.

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* Contribution from the Entomological Laboratory, Cornell University, Ithaca, N. Y.

DIFFERENCES IN THE SCALES.

The new scales formed on apple are of a uniform brown, while the new ones on lilac are traversed by distinct stripes or bands. These bands, three or four in number, are light brown in color and vary in width from those that are quite wide to those that are mere strips. The old scales on apple are of a very dark uniform brown, sometimes of a slight grayish tint. The old scales found on lilac, on the other hand, are of a very pale gray, sometimes almost white, and the bands can be distinctly seen. These differences are uniform and constant in all specimens.

DIFFERENCES IN THE BIOLOGICAL DEVELOPMENT.

During 1919, 1920, and 1921, careful observations were made on the biological development of the insects on lilac. In 1920 and 1921 the biological development of the insects on apple was also studied. The differences in the development of the apple and lilac forms are most clearly shown by means of a table.

	1919	1920		1921	
	Lilac	*Apple*	*Lilac*	*Apple*	*Lilac*
Eggs hatched	June 7	May 31	June 14	May 6	May 27
First molt	June 21	June 16	July 2	June 1	June 20
Second molt	July 17	July 8	July 29	June 24	July 7
Egg laying began	Aug. 19	Aug. 5	Aug. 31	July 22	Aug. 5

It will be seen from the table that the apple form develops from two to four weeks ahead of the lilac form. The cold summer of 1920 seems to have retarded the development of the insects on lilac more than of those on apple, for the lilac insects were nearly four weeks behind those on apple in beginning to lay their eggs. In 1921, however, there was a difference of about two weeks in the development throughout the entire season.

DEVELOPMENT ON DIFFERENT HOST PLANTS.

In connection with the study of the biological development, some transfer experiments were carried on in an effort to learn if the apple and lilac forms are interchangeable as far as host

plants are concerned. Small pieces of twigs, badly infested with scale, were tied to clean, uninfested branches of various trees, each branch being then covered with a bag of fine cheese cloth. In every case the eggs hatched and the young larvæ crawled to the new host plants in large numbers. The results of these experiments were as follows:

TRANSFERS FROM APPLE TO OTHER PLANTS.

Plants to which transfers were made	Result
Lilac, Poplar.	Very successful. Many completed their development and laid eggs.
Willow, Choke cherry, American ash.	Fairly successful and about in the order named. Some completed their development and laid a few eggs.
Red maple.	Many became adult and started the third or permanent scale.
American elm, Box elder.	On the elm, 2-3 became adult, then died. On box elder only one became adult. In both cases many were found to have died in the second instar.
Pussy willow.	None were found in the adult stage. A few started the second scale and then died.

TRANSFERS FROM OTHER PLANTS TO APPLE.

Plants from which transfers were made.	Result
European ash, Lilac (2 places), Willow, Lombardy poplar.	All the larvæ died in the first instar.

TRANSFERS FROM OTHER PLANTS TO PEAR.

Plants from which transfers were made.	Result
Lilac.	Many larvæ were found on the twigs, having died in the first instar. A few had started the first scale.
Large toothed aspen.	Many larvæ formed the first scale, others died without any effort at making one.

It will be noticed that while transfers were successful from apple to other trees, in no case could insects of the lilac form be made to live for any length of time on apple or pear. Although the young larvæ crawled on the apple and pear twigs, in every instance they died while still in the first instar. The scales made by the apple form on the new host plants were always of the uniform brown so constant on the apple.

DIFFERENCES IN MORPHOLOGICAL CHARACTERS.

No differences have as yet been found in the pygidial fringe of the apple and lilac forms. Several writers, however, have called attention to the variation in the number of circumgenital pores of the Oyster-shell Scale from different host plants. For example, Cockerell (1895) mentions finding specimens on dogwood in California that had fewer pores than are usually noted on apple. Frank and Kruger (1900) give sample counts of these pores from apple, plum, thorn, poplar, and willow. Glenn (1920) also counted the pores from various host plants. These observations suggested the desirability of making extensive counts of these pores from insects on apple and lilac. Knowing that a study of the pores would be of little value unless made from a long series of specimens, approximately 550 insects were mounted and their pores counted, 277 from apple and 272 from lilac. Instead of putting the data in tabular form, giving maximum, minimum, and average counts, variability curves were plotted such as are commonly used by workers in genetics to show fluctuating variations. The information desired was not the average number of pores in a group, but the number of pores found to occur most commonly.

The accompanying diagrams show these curves. The abscissæ indicate the number of pores found in the various groups examined, while the ordinates indicate the proportion of groups in which the varying numbers of pores occurred. To make the curve for the posterior lateral groups of the apple form, pores were counted in 496 groups. These pores were found to vary in number from 6–24 in a group. Only one group (0.20% of the total number of groups examined) had as few as 6 pores and only one group had as many as 24 pores. On the other hand, 72 groups (14.51%) had 11 pores, 100 groups (20.16%) had 12 pores, and 80 groups (16.12%) had

13 pores. In the posterior lateral groups of the apple form the number of pores found to occur most commonly, then, is 12. Therefore, speaking technically, 12 is the "mode" of the apple form. The curve for the posterior lateral groups of the lilac form is based on counts of the pores of 485 groups. Of these groups, 64 (13.19% of the total number of groups examined) had 19 pores. The mode of the lilac form, then, is 19. Not a single group of the 485 examined from lilac had 12 pores, while only six (1.20%) of the apple specimens had 19 pores.

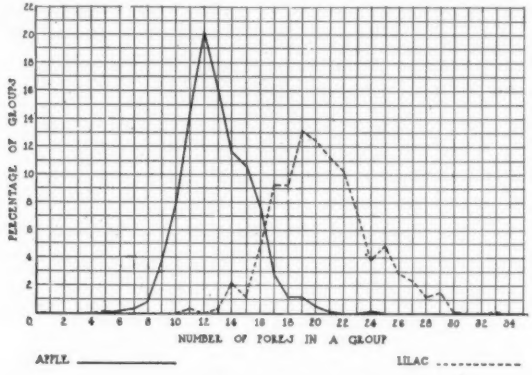


FIG. 1.

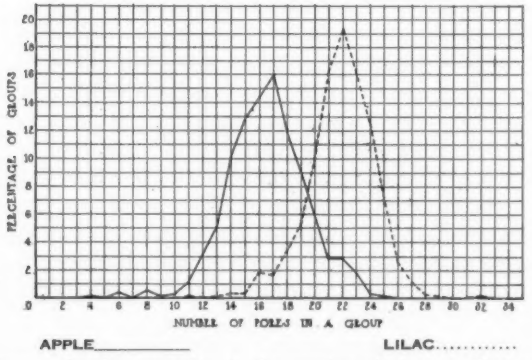


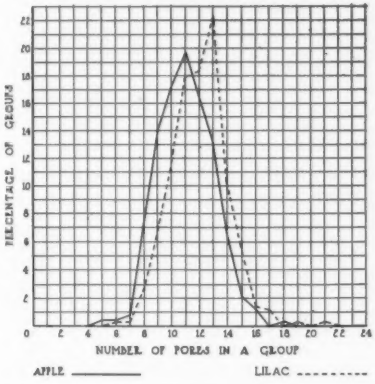
FIG. 2.

Fig. 1. Curves showing variation in the number of circumgenital pores of the posterior lateral groups of the apple and lilac forms. The curves are based on counts of the pores of 496 groups of the apple form and 485 groups of the lilac form.

Fig. 2. Curves showing variation in the number of circumgenital pores of the anterior lateral groups. The curves are based on counts of the pores of 490 groups of the apple form and 485 groups of the lilac form.

Practically the same thing holds true of the anterior laterals. Here the mode of the apple form is 17, while that of the lilac is 22. In the case of the median group the difference is less marked, yet each form has its mode, that of the apple being 11, while that of the lilac is 13. The greatest contrast is seen in

FIG. 3.



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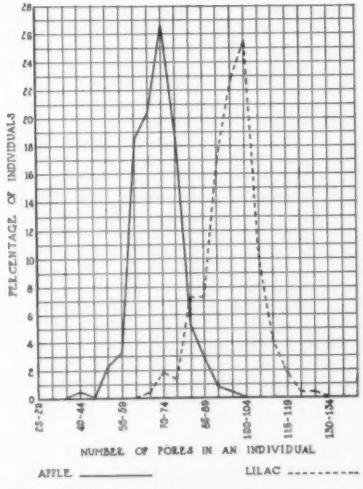

Fig. 3. Curves showing variation in the number of circumgenital pores of the median group. The curves are based on counts of the pores of 243 groups of the apple form and 251 groups of the lilac form.

Fig. 4. Curves showing variation in the total number of circumgenital pores of all five groups. The curves are based on counts of the pores of 210 individuals of the apple form and 220 individuals of the lilac form.

the diagram representing curves for the total number of pores of all five groups. In order to plot these curves at all it was necessary to place the insects in classes with respect to the number of pores, for example, those having 65–69 pores, 70–74, 75–79, etc. The curve for the apple form shows that the total number of pores for an individual is most commonly 70–74. In other words, the mode of the apple form is 70–74, while that for the lilac form is 100–104. Only five insects of the 220 examined from lilac had as few as 74 pores, while not a single apple insect was found to have 100 pores, and only three had as many as 90.

A study has been begun of the pygidium of the second instar. This pygidium resembles, in many ways, that of the adult insect, though of course, it lacks entirely the circumgenital pores. The dorsal and marginal gland openings can be distinctly seen, there being eight marginal gland openings (four on each side) in both the apple and lilac forms. Sufficient material was not available for a careful study of the dorsal gland openings, but all the specimens examined showed more of these openings present in the lilac than in the apple form. In the lilac form they varied from 14–18, while in the apple they ranged from 8–12. It is planned to secure during the coming summer, material for a more careful study of the gland openings of the pygidium of the second instar.

HOST PLANTS OF THE TWO FORMS.

Examination of the scales and counts of the circumgenital pores show that insects found on the following host plants belong to the apple form:

Red dogwood (Cornus alba).
Alternate leaved dogwood (Cornus alternifolia).
Round leaved dogwood (Cornus rugosa).
Mountain maple (Acer spicatum).

The biological development of the insects on red dogwood, which has been studied, paralleled that of the apple form.

The lilac form was found on:

American ash (Fraxinus americana).
European ash (Fraxinus excelsior).
Fringe tree (Chionanthus virginica).
Golden current (Ribes aureum).
Laurel leaved willow (Salix pentandra).
Heart leaved willow (Salix cordata).

New Jersey Tea (Ceanothus americanus).
Large toothed aspen (Populus grandidentata).
Carolina poplar (Populus eugenii).
Lombardy poplar (Populus nigra, var. italica).
Trembling aspen (Populus tremuloides).
Witch-hazel (Hamamelis virginiana).

The biological development of the individuals occurring on American ash, European ash, fringe tree, laurel leaved willow, large toothed aspen, and Lombardy poplar has been followed and found to agree closely throughout the life cycle with that of the lilac form.

In conclusion it may be said that the evidence certainly seems to justify an affirmative answer to the question, "Are there two species of the Oyster-shell Scale?"

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A STUDY OF THE WING VENATION OF THE COLEOPTERA.*

By S. A. Graham.

The purpose of the modern taxonomist is not satisfied by the mere arbitrary naming of an insect. Taxonomy is more than that. If the worker in this field is true to the highest ideals of his profession he must continually strive to clear up some of the multitude of problems associated with the natural relationship of the organisms with which he is dealing, and to show this relationship in his classifications.

Unfortunately valuable phylogenetic characters are sometimes accidentally overlooked and remain in obscurity. It is not until we take advantage of all these available characters that we can hope to arrive at a true expression of phylogenetic relationship.

In the Coleoptera the characters to be found in the hind wings are undoubtedly of considerable value, but have been almost entirely neglected in taxonomic studies. This is

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perhaps partly due to the fact that these organs are hidden from view beneath the elytra and cannot be studied without relaxing dried specimens, and partly due to the fact that the homologies of the wing veins of this order have never been thoroughly worked out. It is the object of this paper to show in a preliminary way some of the neglected possibilities of these organs in the taxonomy of the group, and to show how the venation of the Coleoptera may be homologized with that of other orders. In this study a large series of wings, representing the most important families of the order, has been examined, but the work is still far from complete.

On examining a series of Coleopterous hind wings, several general outstanding features are apparent. First, that there is a distinct type of venation characteristic of the order. This is remarkably constant when the size of the group is considered. Second, there is considerable similarity between the venation of beetle wings and that of other insect orders, indicating the common origin of winged insects. Third, that within the order Coleoptera there are several types of modification which may have phylogenetic significance.

A study of the literature, however, fails to reveal any comprehensive investigations presenting conclusive evidence as to the homology of the wing veins of Coleoptera with that of other insect orders.

THE RELATION OF FOLDING TO VENATION.

One of the most striking features characterizing the wings of the Coleoptera is the fact that they are not only folded longitudinally, but also have at least one definite transverse fold. The advantage to the insect of this type of folding is obvious as it results not only in narrowing, but also in shortening of the wings when these appendages are folded against the body. This brings the wings under the elytra for protection. This protection is particularly essential to an insect of retiring habits living in places where an unprotected wing membrane would almost certainly be torn.

The fact that these folds or furrows necessarily follow the lines of least resistance between veins, usually running parallel with, and often very close to a vein, led Woodworth to associate them with the formation of veins. There is obviously some

correlation between these two structures, but it seems to be more probable that folding was a modification coming after the development of wing veins and that the position of the folds was influenced greatly by the position of the veins. The folds naturally would follow along lines of least resistance, thus bringing about a mutual adjustment of position between folds and wing veins.

As a rule the folds lie parallel to veins, but if the venation becomes so modified that a fold must cross a vein the result is often a thinning if not an actual break in the vein at the point of crossing, similar to the bullæ so common in the Hymenoptera. The crossing of a vein by a fold is usually nearly at right angles in the order Coleoptera.

TRACHEATION AND VENATION.

In most orders of insects the tracheation of the pupal wing furnishes the key to the wing venation, but in the Coleoptera the tracheation is of little assistance. In this study the tracheation of only a few species has been examined, but in these there was considerable variation within a single species, (*Tribolium confusum*). Further study may show a correlation between these structures in the more primitive types, but for the present we may assume that the primitive position of the tracheæ is probably better indicated by the position of the wing veins which, in some groups of this order approach very closely the primitive hypothetical type of Comstock and Needham.

HYPOTHETICAL PRIMITIVE COLEOPTEROUS TYPE.

By the comparison of a large series of wings representing most of the families of the Coleoptera it has been possible to develop theoretically an hypothetical primitive type of venation for this order which does not differ greatly from the hypothetical primitive type of the class Hexopoda as proposed by Comstock and Needham. The Coleopterous type is characterized by a single branched Sc, a fusion of R_3 and R_4 at their tips, and by a similar fusion of R_5 and M_1. Also the first forks of R, M, and Cu are typically well toward the base of the wing. (Fig. 1).

Briefly, costa lies in the front margin. The next vein behind costa is the single branched sub-costa. Radius is five branched, the radial sector leaving R_1 near the base. R_2 turns forward to the front margin, while R_3 fuses with R_4 and R_5 fuses with M_1. The other veins do not depart from the hypothetical type of the Hexopoda in general; media being four branched, cubitus being two branched, and the three anals being present.

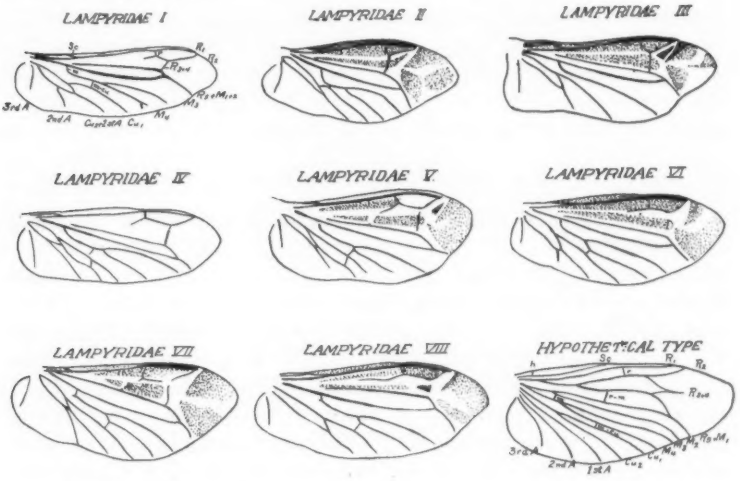

FIG. 1.

I. *Calopteron reticulatum* Fab.
II. *Podabrus tricostatus* Say.
III. *Chauliognathus pennsylvanicus* Fab.
IV. *Photinus pyralis* Linn.
V. *Photinus marginalis* Lec.
VI. *Eros aurora* Herbst.
VII. *Pterotus obscuripennis* Lec.
VIII. *Caenia dimidiata* Fab.
IX. Hypothetical Coleopterous Type.

COLEOPTEROUS WINGS IN GENERAL.

It is possible that costa is not always present, but whenever it occurs, it always lies in the front margin.

Sub-costa lies in the normal position and usually fuses with R_1.

Radius 1 lies just behind Sc and is always close to the front margins of the wing. In some species R_1 is so thickened as to almost obscure Sc.

The Radial sector leaves R_1 near the base of the wing and soon branches. R_2 turns forward to the margin, often fusing

with R_1. R_3 turns backward and fuses with R_4. In the majority of Coleopterous wings R_3 and R_4 form a cross vein between R_2 and R_5, but the various stages leading up to this condition are found in species of several families, for example, Cerambycidæ, Chrysomelidæ, Bostrychidæ, Spondylidæ, etc. (See Fig. 3). In every wing examined, the radial sector is broken at the base and in many cases the basal part is entirely gone.

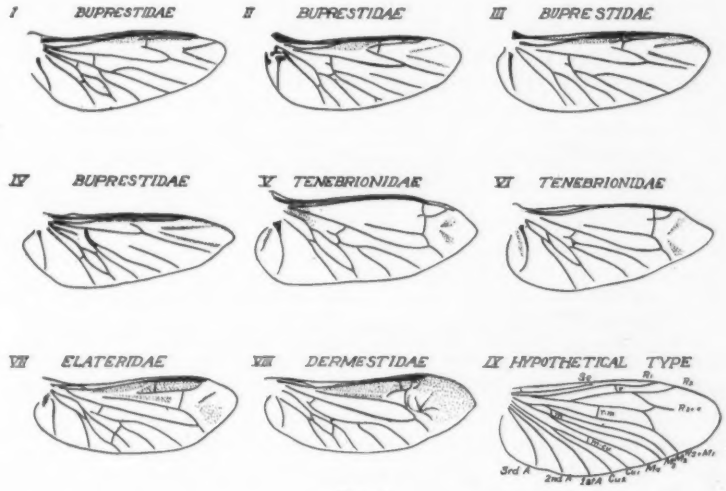

FIG. 2.

I. *Buprestis fasciata* Fab.
II. *Dicerca tenebrosa* Kby.
III. *Dicerca divaricata* Say.
IV. *Choleophora liberta* Germ.
V. *Upis cerambycoides* Linn.
VI. *Nyctobates pennsylvanicus* De G.
VII. *Elateridae*
VIII. *Dermestes lardarius* Linn.
IX. Hypothetical Coleopterous Type.

Media is typically four branched, but in the Coleoptera M_1 and M_2 are always coalesced so that they appear as a single vein. The first fork of M is near the base. Usually the basal part of branch M_3 and M_4 is lost up to the medial cross vein so that the cross vein appears to be the base of that branch. The lost basal part is, however, often indicated by a spur or in a few cases may be present as in *Buprestis fasciata*. (Fig. 2-I).

Cubitus is always two branched, but these may be fused at the tip. Three anals are typically present and the 3 A is

almost always separate from the other two. 1 A may either anastomose or coalesce with Cu and seldom appears as a separate vein for its entire length, while 2 A is usually fused with 1 A at least at the base.

The usual cross veins are found represented in the order, but it is unusual to find a wing in which they all occur. The humeral cross vein is usually either absent or obscured by the thickening of the veins in that region. Radial cross vein is almost always present. The Radio-medial cross vein is absent except in a single group of families of which the Carabidæ are typical. The medial cross vein and the medio-cubital cross veins are usually found normally.

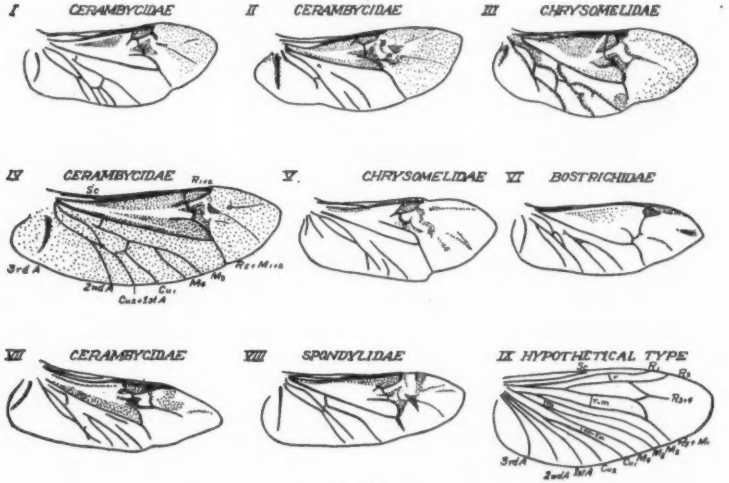

FIG. 3.

I. *Acaemops bivittatus* Say.
II. *Tetraopes femoratus* Lec.
III. *Chrysochus auratus* Fab.
IV. *Desmocerus palliatus* Forst.
V. *Donacia* sp?
VI. *Bostrychus bicornus* Web.
VII. *Monohomus confusor* Kby.
VIII. *Parandra brunnea* Fab.
IX. Hypothetical Coleopterous Type.

LINES OF MODIFICATION.

One of the most striking lines of modification is to be found in the fusion of tips of the veins in the apical area and a pushing back of the primary venation toward the base of the wing. The veins are replaced by secondary solid thickenings or

calosities in the apical area which often resemble veins so closely that it is only by the study of a series of wings that their origin becomes clear. The presence of these secondary vein-like calosities has undoubtedly led to much confusion in studies of the wing venation of this order. In the plates these structures are indicated by stippling, while the true veins are represented by solid lines.

The pushing toward the base of the primary venation, as mentioned above, is apparent in the most primitive types of Coleopterous wings studied, but is much more striking with increased complexity of folding. The extreme of this modification is found in the Staphylinidæ, but a highly specialized condition is also apparent in other widely separated families such as the Scarabaeidæ, Silphidæ, Nitidulidæ, Ipidæ, and Curculionidæ. Thus it appears that this line of modification is correlated with the complexity of folding. Increased complexity of folding is made necessary in two ways. Either by a shortening of the elytra as in the Staphylinidæ or by shortening and thickening of the body, thus decreasing the elytral length as compared with the wing length as in the Scarabaeidæ.

Along with this migration of the primary venation toward the base of the wing and due also to increased complexity of folding, there occurs a reduction of veins. Also many veins become broken and branches become entirely separated from the veins of their origin.

PHYLOGENETIC SIGNIFICANCE.

It is apparent that the final determination of phylogenetic relationship cannot be based upon wing venation alone any more than it is possible to base such relationship upon tarsal, thoracic, or any other set of characters alone. The wings do, however, give some hints which will undoubtedly be of considerable value when correlated with other characters.

The first point which is brought out in this study is that the Lampyridæ, using that term in its broad sense, are characterized by a much simpler type of venation than any other group of the order. The venation of this family approaches very closely what was probably the primitive type. This, coupled with the fact that the Lampyridæ exhibit other primitive characters, such as soft wing-like elytra, soft integument, a larger number

of abdominal segments than usual in this order, elongate body form, and long, many-jointed antennæ, would seem to justify the suggestion that this family may represent the most primitive of modern beetles. If this is true, it seems probable that the Coleoptera had its origin in a Lampyrid-like ancestral form.

On the other hand, the Carabidæ exhibit a distinct and rather a specialized type of venation which is characteristic of a group of families, including the Gyrinidæ, Dytiscidæ,

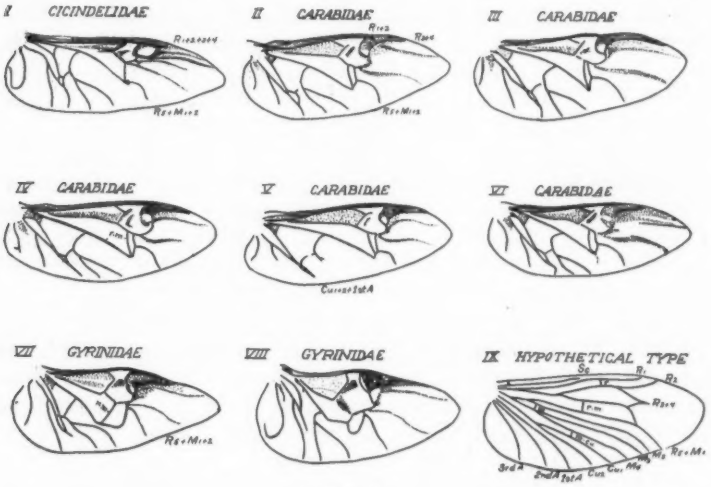

FIG. 4.

I. *Cicindela vulgaris* Say.
II. Carabidae.
III. *Harpalus caliginosa* Fab.
IV. Carabidae.
V. Carabidae.
VI. *Anisodactylus discoideus* Dej.
VII. *Gyrinus analis* Say.
VIII. *Dineutes assimilis* Aube.
IX. Hypothetical Coleopterous Type.

Cicindelidæ, and probably others. (Fig. 4). This group is characterized by the presence of cross veins r – m, by the persistence of the fused part of R_3+R_4 which turns forward to the margin of the wing, and by the fact that the transverse fold cuts through branches R_{2+3} and R_4 leaving these veins in the apical part of the wing.

The Cerambycidæ and Chrysomelidæ typify another group of families having similar venation. This type includes a large

proportion of the families of Coleoptera, for example, Buprestidæ, Tenebrionidæ, Elateridæ, Bostrychidæ, Spondylidæ, Cistelidæ, Melandryidæ, Oedermeridæ, Pythidæ, Trogositidæ, Erotylidæ, Colydidæ, Mycetophagidæ, Mordellidæ, Meloidæ, and others.

This group is characterized by the fading out of the fused part of R_{3+4}, leaving a straight vein between R_2 and R_4. The

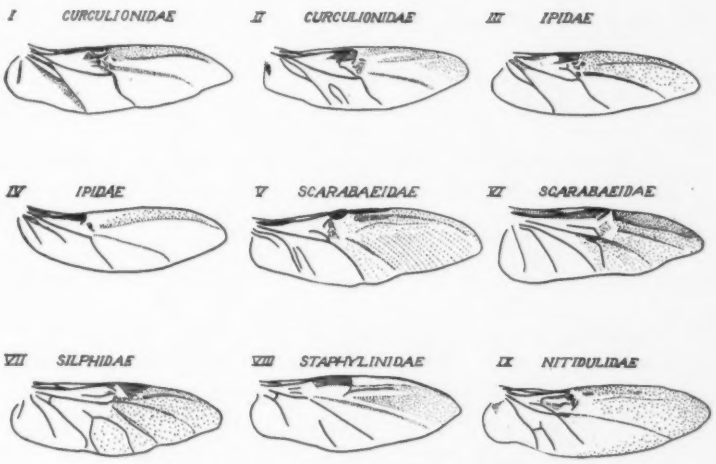

FIG. 5.

I. Curculionidae.
II. *Pissodes strobi* Peck.
III. *Hylobius* sp?
IV. *Ips* sp? (Ipidae).
V. *Bolbocerus lazarus* Fab.
VI. *Osmaderma eremicola* Kn.
VII. *Silpha inaequalis* Fab.
VIII. Staphylinidae.
IX. *Ips sanguinolentus* Oliv. (Nitidulidae).

various steps of this process are shown in species of Cerambycidæ, Chrysomelidæ, Spondylidæ, and Bostrychidæ. The transverse fold in this group cuts off the primary venation from the apical area of the wing.

We still have left a group of wings which have become so specialized that the venation gives very little hint of possible relationships and need not be discussed except to say that a number of widely separated families are represented. (Fig. 5).

SUMMARY.

1. A large series of hind wings, representing most of the important families of the Coleoptera, have been examined and the following conclusions seem justified:
2. The hypothetical primitive type of Coleopterous wing does not differ greatly from the Hypothetical type proposed by Comstock and Needham for the Hexapoda in general.
3. The hypothetical Coleopterous type is characterized by a fusion of R_3 with R_4 at the tip and by a similar fusion of R_5 and M_1.
4. The usual cross veins are typically present.
5. Modification of the venation goes hand in hand with an increase in the complexity of folding.
6. In general there are two types of modification:
   (a) A pushing back of the primary venation toward the base of the wing and the substitution of secondary thickenings in the apical area.
   (b) The reduction and breaking up of the veins.
7. The types of venation fall naturally into four groups.
   (a) Represented by the Lampyridæ which is the simplest type and may indicate the possibility of a Lampyrid-like ancestral form for the Coleoptera.
   (b) Represented by the Cerambycidæ and Chrysomelidæ in which R_3 and R_4 have become a simple cross vein between R_2 and R_5, and where the primary venation is cut off from the apical area.
   (c) Represented by the Carabidæ which is characterized by the persistence of the fused portion of R_3 and R_4, the presence of cross veins r – m, and the cutting of R_{2+3} and R_4 by the transverse fold.
   (d) A group of widely separated families where the venation is too highly specialized to show any relationship.